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# TILLAMOOK BAY DRAINAGE BASIN EROSION AND SEDIMENT STUDY OREGON

## MAIN REPORT



A Cooperative Study by:

The Tillamook Bay Task Force and The Oregon State Water Resources Department  
and  
The United States Department of Agriculture Soil Conservation Service  
Forest Service-Economics, Statistics, and Cooperatives Service

1978

The report for the Tillamook Bay Drainage Basin Erosion and Sediment Study consists of three separate documents as follows:

#### SUMMARY REPORT

The Summary Report is brief and nontechnical. It is intended for general information and should not be used as a source for planning and management decisions. It describes the study area and the erosion-sediment problems. It highlights the study and discusses management techniques for dealing with problems.

#### MAIN REPORT

The Main Report contains a detailed description of the area, the erosion-sediment problems, the study procedures, and managerial strategies for sediment reduction with related costs and impacts. It is written and organized for planners, land managers and decision makers to utilize in doing their job.

#### APPENDICES

The appendices contain numerous detailed tables on erosion and sediment input and output data. The tables are developed by subareas within the five river subbasins. They are color coded to the five river subbasins shown on the Study Area Map.

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## CHAPTER I

### SUMMARY



# SUMMARY

## NEED FOR STUDY

Sediment in Tillamook Bay is a major problem. The continual deposition of sediment in the bay has caused adverse effects on shipping and navigation, commercial and sports fishing, oyster production and clamming, and on environmental and aesthetic qualities of the basin. Sediment is the primary problem that prompted the Oregon State Water Resources Department and the Tillamook Bay Task Force to request the U.S. Department of Agriculture to conduct this study.

Erosion, the major cause of sediment, is also a severe problem in many places throughout the Tillamook Bay Drainage Basin. Channel banks, land slides, roads, old burned areas and clearcuts are some of the most noticeable major erosion source areas. Study of erosion problems was essential in order to find ways of reducing sediment.

## SETTING AND RESOURCES

### GEOGRAPHIC

The Tillamook Bay Drainage Basin is located in northwestern Oregon. It is bounded on the east by the crest of the Coast Mountain Range and on the west by the Pacific Ocean. The three resource areas considered in this study cover a total of 363,520 acres of which 323,050 acres are brush, cutover, and forested land on moderate to steep slopes and deeply incised canyons; 29,490 acres are non-forest and flat to gently sloping urban, agricultural and miscellaneous land; and 10,980 acres include the rivers and bay area.

Tillamook Bay is located 48 miles south of the mouth of the Columbia River and 60 miles west of Portland, Oregon. The bay is about six miles long in a southeast to northwest direction, two miles wide, less than six feet in average depth, and is barred with only a 1200 foot opening to the ocean. A sand spit, Bayocean Peninsula, extends from the south to near the north side of the bay where jetties have been constructed to facilitate entrance to the bay. Four large rivers, the Wilson, Trask, Kilchis and Tillamook enter the bay from the southeast while a fifth large river, the Miami, enters from the north and just opposite the entrance to the bay from the Pacific Ocean.

### CLIMATIC

The strong marine influence of the Pacific Ocean dominates the climate in the Tillamook area. Wet winters and moderately dry summers

characterize the region, and temperature ranges are narrow. Frequent storms from the southwest between November and March bring heavy rainfalls over short periods. Average annual precipitation for the drainage basin is 115 inches, with a 90-inch average at Tillamook and up to 150 inches at higher elevations.

The average temperature is 42<sup>0</sup> F in January and 58<sup>0</sup> F in July. Temperatures seldom drop below freezing near the shoreline of the bay. The basin has a growing season of 190 days without a killing frost. Fog is common throughout the year, particularly during night and morning hours.

### BIOLOGIC

Tillamook Bay and the streams and lands within the basin provide habitats for diverse fish and wildlife species. All of the major perennial streams are used by anadromous fish. The bay is rich with vegetation and organic nutrients which contribute to high productivity of oysters, clams, crabs and other shellfish.

### ECONOMIC

Over 90 percent of the land in the Tillamook Bay Drainage Basin is classified as forest. The wood products industry, including logging, sawmills and plywood operations, timber holdings, and associated service activities, accounts for about 43 percent of the total gross county output.

The principal agricultural activity is dairy farming and related food processing. These sectors, together with other minor farming, make up about 17 percent of the total gross output.

The remaining gross output, about 40 percent, comes from construction, transportation, recreation, manufacturing, seafood, utilities, and services.

## OBJECTIVES

The major objective was to propose methods of reducing sediment entering Tillamook Bay. A corollary objective was to insure sediment reduction at least cost.

In order to analyze the problems and derive sediment reduction alternatives, several study objectives were accomplished:

- (1) To inventory the gross erosion rates by suitable categories under present conditions;

- (2) To estimate the sediment yield under existing use and management;
- (3) To develop and evaluate alternative measures and land use management plans;
- (4) To estimate future sediment yields for various alternative land management plans;
- (5) To assess economic effects of soil erosion and sedimentation and evaluate economic consequences of proposed alternative solutions or plans;
- (6) To recommend opportunities for implementation of erosion and sediment control measures.

## PROCEDURES

The study objectives were accomplished by using both commonly accepted and, where necessary, innovative and new techniques and procedures. Erosion and sediment samples were taken from 160 sample plots and 14 stream gaging stations, respectively, over a two-year period. Aerial low-level photography, taken at different time periods, was analyzed and compared to assist in evaluating streambank erosion. Analysis and evaluation of the nature and extent of erosion problem areas was aided by the use of space-age earth satellite telemetry. Hundreds of hours were spent by the study staff and others conducting on-the-ground examinations and field investigations of erosion and sediment problems. The bay was sampled at 52 surface sites and at 14 core sites. All of the known published and unpublished materials related to Tillamook were studied, compared and evaluated. Technical information was obtained from specialists and experts in several different scientific disciplines, from universities, from agencies of state and federal government, and from consultants and individuals with expertise in specialized subject matters. An erosion and sediment computer model was programmed for the basin to determine least cost alternatives of sediment reduction.

Many meetings were held and individual contacts were made with concerned and knowledgeable citizens in Tillamook County during the course of the study. As a result of public involvement, many improvements were made in methodology and procedures as the study progressed.

## FINDINGS AND CONCLUSIONS

Sediment enters Tillamook Bay at the rate of about 61,000 tons annually. Eighty-five percent, 51,600 tons, originates on the forested, upper watershed, which comprises about 90 percent of the total land area of the basin. Fifteen percent, 9,400 tons, comes from agricultural and urban lands adjacent to the bay.

Much is already being done to control erosion and sediment, but more can be accomplished. While the study does not propose an implementation plan, it does present and compare several alternative sediment reduction levels, at 10 percent increments. The maximum sediment reduction evaluated was 64 percent, about 38,800 tons. The 64 percent reduction could be achieved with present technology and commonly used control practices; however, the installation costs would be high, 189 million dollars (at 1975 prices).

A 30 percent sediment reduction, about 18,200 tons, would require installation expenditures of approximately 2.5 million dollars. Average annual costs would be about \$171,000. Annual benefits came to about \$273,000, leaving \$102,000 net positive benefits. The 30 percent level could be achieved by stream stabilization measures; tree planting on landslides, clearcuts, and burns; and by closing and stabilizing some roads on forested lands.

## DEVELOPMENT OF USDA PROGRAMS

Future implementation of a sediment reduction plan (not an intended objective of this study) offers opportunities for development of existing USDA programs as well as programs of many other agencies. The Emergency Watershed Protection Program (Sec. 216 of Public Law 81-516) is the most widely used program at the present time for stabilization of channel banks eroding as a result of major storms. The Agricultural Conservation Program has also been utilized to a limited degree in on-farm correction of sediment and erosion problems. The State Forest Practices Act may be applied in reforestation programs on forested lands in the basin.

Other implementation ideas and suggestions were discussed. A list of federal programs that may potentially offer assistance, or in some way relate to implementation, are presented in Chapter X of this report.

## CHAPTER II

### INTRODUCTION



# INTRODUCTION

The U.S. Department of Agriculture (USDA) has completed a study of erosion problems and sediment deposition in the Tillamook Bay Drainage Basin. The study was made at the request of the Oregon State Water Resources Department. The agencies involved in the study by cooperative agreement are the Soil Conservation Service (SCS); Economics, Statistics, and Cooperatives Service (ESCS); and the Forest Service (FS). The SCS is responsible for overall leadership, with the ESCS and the FS participating. The results of the study may be used as a basis for the development of coordinated programs for controlling erosion in the upper watershed and reducing sediment deposition in Tillamook Bay Estuary.

The objectives of the study are to: (1) Inventory the gross erosion rates by suitable categories under present conditions. (2) Estimate the sediment yield under existing use and management. (3) Develop and evaluate alternative measures and land use management plans. (4) Estimate future sediment yields for various alternative land use management plans. (5) Assess economic effects of soil erosion and sedimentation, and evaluate economic consequences of proposed alternative solutions or plans. (6) Recommend opportunities for implementation of erosion and sedimentation control measures.

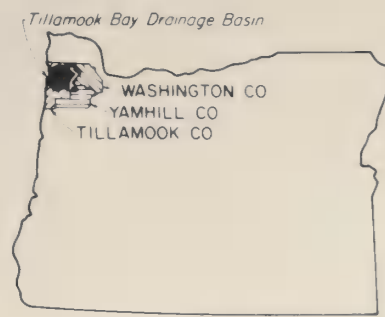
A public participation and involvement program was initiated early in the study. The Tillamook Bay Task Force served as the local steering committee and coordinated local public involvement. This provided an opportunity for interested groups, agencies, and individuals to review, comment, and participate in the study.

The Tillamook Bay Drainage Basin, located in the northwestern part of the state, is bounded on the east by the crest of the Coast Mountain Range and on the west by the Pacific Ocean. The three resource areas considered in this study cover a total of 363,520 acres of which 323,050 acres are forested land on moderate to steep slopes and deeply incised canyons; 29,490 acres are non-forest and flat to gently sloping urban, agricultural and miscellaneous land; and 10,980 acres contain water resources which include the rivers and Tillamook Bay Estuary.

Several agencies and organizations including the Tillamook Soil and Water Conservation District provided helpful assistance. The Tillamook field office of the Soil Conservation Service furnished much of the basic data related to soil types, past flooding conditions, past programs related to erosion control, and coordinated personnel for installing and measuring stream gages and obtaining water samples for laboratory quality analysis.





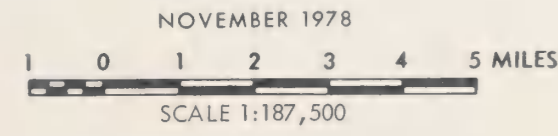


LOCATION MAP

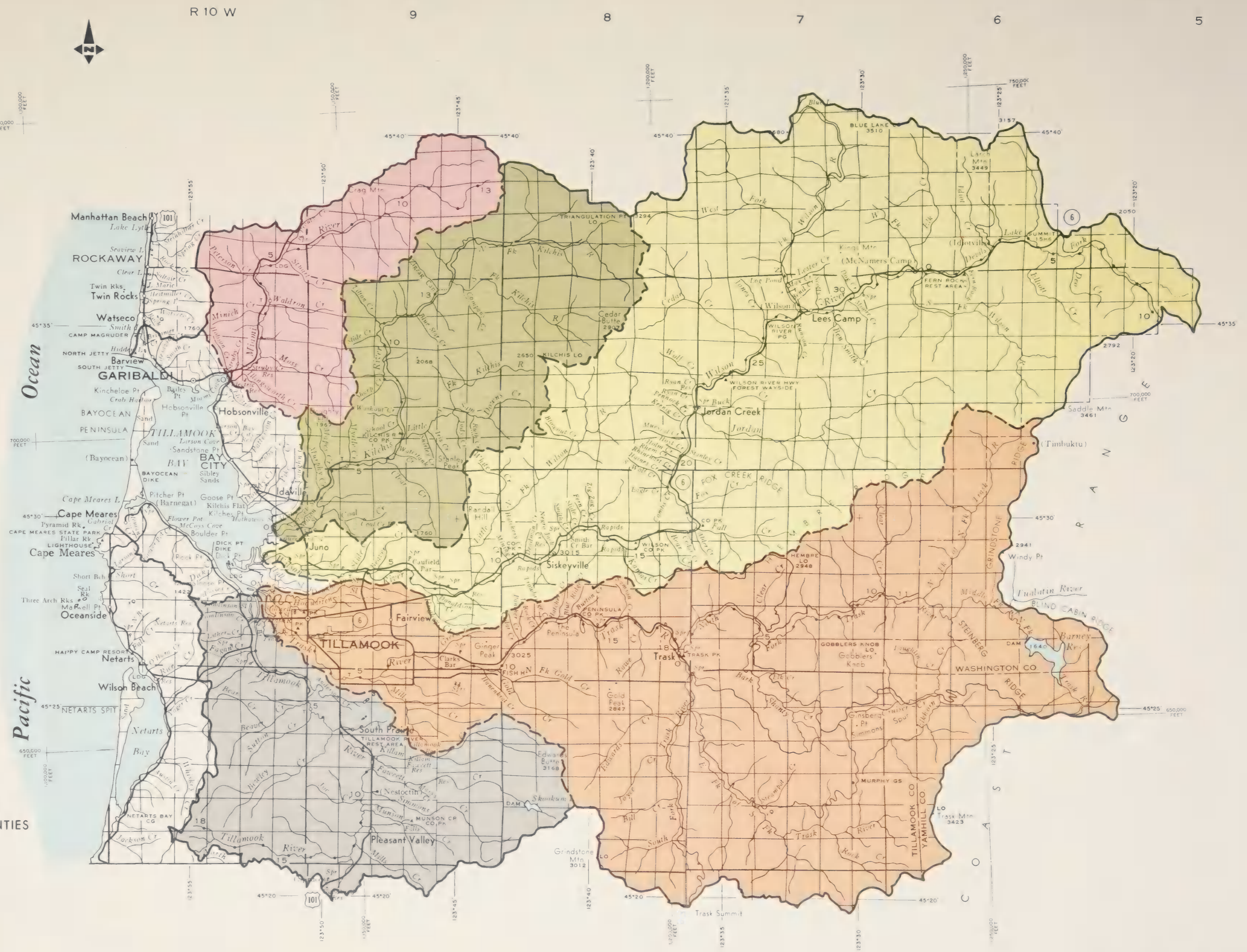
MAJOR SUBBASINS

- Miami River
- Kilchis River
- Wilson River
- Trask River
- Tillamook River

STUDY AREA MAP  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES  
OREGON



Sources:  
Base map furnished by Oregon State Staff.  
Thematic detail compiled by State Staff from SCS field surveys.  
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE. USDA-SCS-PORTLAND, OR. 1978



In 1976, under a cooperative agreement between the U.S. Geological Survey and the U.S.D.A. an extensive drilling and soil sampling program in Tillamook Bay Estuary was undertaken to provide a historical record of sedimentation. Samples were made available for comparative analysis and along with logs, test results and interpretations are included in this report. The Oregon Department of Environmental Quality conducted the analysis of the water quality samples.

Assistance on forest lands was provided by the local State Forester's office. Under a contract agreement between the U.S. Forest Service and the Earth Resources Remote Sensing Applications Laboratory (ERSAL) at Oregon State University, satellite imagery was utilized. The LANDSAT (PIXSYS) computer program was used to obtain data on land use and individual acreages based on cover conditions, both of which were used in the determination of erosion and sediment yields.

The study consisted of accumulating and evaluating previously recorded data, both published and unpublished. In addition, field observations and soil and water quality sampling programs were carried on by both the Soil Conservation Service and the Forest Service to gather additional basic data. This included physical characteristics of the watershed slopes, streambanks, streambottoms, agricultural lands, and the problems and needs of each tributary sub-watershed. The ESCS constructed and operated a linear programming computer model which was used to determine least-cost land treatment measures that would result in specific levels of sediment reduction in Tillamook Bay.

The distribution of the three-part study report includes a public information program on the contents of the reports. Assistance will be provided for those using the report as a planning or land management guide.

## USER'S GUIDE

The results of this study are presented in three reports, the Summary Report, the Main Report and the Appendices. The three reports are described briefly inside each cover.

Readers of these reports will have various general and specific areas of interest. The Summary Report's concise nontechnical discussion of the study and the problems may be adequate for many. The Main Report includes tables and maps concerning natural resources of the area. These can be easily located by using the Expanded Table of Contents. For those primarily interested in sediment reduction in Tillamook Bay and how this study can be used as a planning tool, time can be saved by following the User's Guide.

This report does not propose "a plan". Instead, the Main Report presents several control programs at different levels of sediment reduction. At each level the control program presented is the least-cost program. Selection of a sediment-reduction goal is the first step. Many factors may affect the selection of a goal. The amount and sources of funding may be one factor. Another factor could be the amount of sediment reduction desired, in relation to fish, habitat, channel maintenance, etc.

The User's Guide presents a narrated, step-by-step example of how the report can be used to guide planning and management decisions. The steps followed in the example are summarized as a flow chart following this guide; see Chart I, User's Guide.

### Where Does One Start?

A level of sediment reduction is selected based on financial, biologic and other considerations. Various levels might be assumed for making comparisons and testing viability of proposals being considered.

#### Step 1. Sediment-Control Programs

Turn to page X-6, Table X-2, for a comparison of sediment-control programs. Suppose the goal is to reduce sediment by 20 percent. Under Levels of Reduction, 20% column, are shown beneficial and adverse effects.

#### Step 1A. Implementation

For some thoughts on implementation of sediment control, see pages X-7 through X-8, and Table X-3.

#### Step 2. Control Measures - Summaries

Summaries of sediment-control measures required for the least-cost 20 percent reduction are shown on Tables IX-12 and IX-13 (pages IX-29 and IX-30). The first table is for "agricultural" lower watershed lands. The second table shows acres of treatment measures required on "forested" upper watershed lands.

#### Step 3. Sediment Source Areas - Summaries

Go to Tables IX-16 and IX-17, pages IX-35 and IX-36, for a summary of acres of sediment-source areas on which treatments would be applied. At the 20 percent level, stream channel banks, clearcuts, and burns would be treated for a least-cost solution.

#### Step 4. Treatments and Source Areas

Steps 2 and 3 are shown in more detail on Table X-1. Here the acres of treatment measures are delineated by each sediment-source area. Also shown under the cost effectiveness column are the sediment reductions, 12,120 yards at 20 percent, and the per yard and total net benefits, \$6.39 and \$77,440, respectively. Another useful piece of information is found under the column, Institutional Constraints, where the total installation costs are shown, \$893,000 for the 20 percent level.

#### Step 4A. Scenarios and Levels

In the same table, under the column, Achievement of Desired Results, are found gross sediment reductions as percentages of various results that could be obtained under differing assumptions. For example, at the 20 percent reduction, Scenario A, Level II, 38.2 percent of the objective would be met. To achieve 100 percent of the Scenario A, Level II objective or goal, river sediments would have to be reduced by 19,000 tons (see pages X-1 through X-2 which explain the different scenarios and goal levels).

#### Step 4B. Management Strategies and Study Limitations

Before going further in considering a particular plan, one should be aware of some of the limitations and alternative strategies that pertain to this study. A brief narrative can be found on pages X-9 through X-12.

#### Step 5. Acres Treated By Subbasin

Finally, it is determined which subbasins are to be treated. Turn to pages IX-32 and IX-33, Tables IX-14 and IX-15 for summaries of control measure acres by subbasin. For a 20 percent, least-cost reduction, 2,176 acres of forested lands would be treated and only about 6 acres of agricultural lands.

AT THIS POINT A PRELIMINARY PLAN CAN BE FORMULATED

#### Step 6. A Detailed Account

The next steps develop the specifics of the plan. A detailed account of acres of treatment measures, by source areas, by subbasin, for agricultural and forested lands can be found in the Appendices.

Portions of the Appendices are color coded. Each of the 5 principal subbasins is represented by a different color. Thus, tables pertaining to the Miami subbasin, for example, are all the same color. For those interested in a particular subbasin, pages of the same color can be quickly referenced.

#### Step 6A. Example of Detailed Account

An example of the appendix LP (linear programming) output tables is found on pages IX-23 through IX-27, Tables IX-7 through IX-11. This example, for the 20 percent reduction, consists of five tables. The first two tables, for the Kilchis, Lower Main Stem, illustrate the detailed information available throughout the Appendices. The next two tables are summaries of the first two. The fifth table is a summary of the 20 percent reduction over all subbasins.

#### NOTE: BASIC EXAMPLE IS NOW COMPLETED

The foregoing example shows where to find information relating to various alternative plans and treatment measures that can be used to control sediment. More information is contained in the study. For example, Step 8 mentions the map, Potential Surface Erosion Hazard, which could assist in selecting specific sites for certain treatment measures. Data collection methods may be of interest for consideration of specific values. The following steps are not all necessary in every case and they are not necessarily sequential. They are presented for the user's general guidance.

#### Step 7. Input Data Tables

In the Appendices section of this report are found the tables of input data used in the analysis of least-cost treatment alternatives.

#### Step 7A. Brief Example of Input Data

An example of the appendix input tables has been included in the Main Report (pages IX-16 through IX-17, Tables IX-4 and IX-5). These examples are again for a 20 percent reduction for the Kilchis, Lower Main Stem. The input tables show the per acre sediment rates for 1975, as well as rates for each control measure. The tables also show the acres of each source as well as the costs per acre, of sediment control measures.

#### Step 7B. More Data and Summary of Model

Additional narrative and tables pertaining to treatment measures and costs are found on pages IX-7 through IX-11. A brief explanation of the linear programming model and input data is found in the Main Report (pages IX-14 through IX-21).

## Step 8. How Were the Data Obtained?

Chapter VI, Erosion and Sediment Yield Studies and Survey Procedures, should be read by those interested in the derivation of the data base. Survey procedures and results for both agricultural and forested lands, and for erosion and sediment, are set forth in this chapter. The following maps in the Main Report should be of special interest:

Recording Gages and Sediment Sampling Stations

Soil Samples and Erosion Plots

Potential Surface Erosion Hazard

Gross Erosion and Sediment, Forest Lands.

The data shown on these maps are the basis for all the analysis of least-cost sediment control alternatives.

## Step 9. Historical Development

For those unfamiliar with the Tillamook Drainage Basin, Chapter III is important. Local residents are familiar with historical development of the Tillamook Bay sediment problem. Others may not be aware of the many fires and floods and other factors affecting erosion and sediment in the area.

## Step 10. Resource Inventories

For those interested in the natural resources of the area, see Chapter IV, Resource Inventory Summary. Resource management guidance is also included in this chapter.

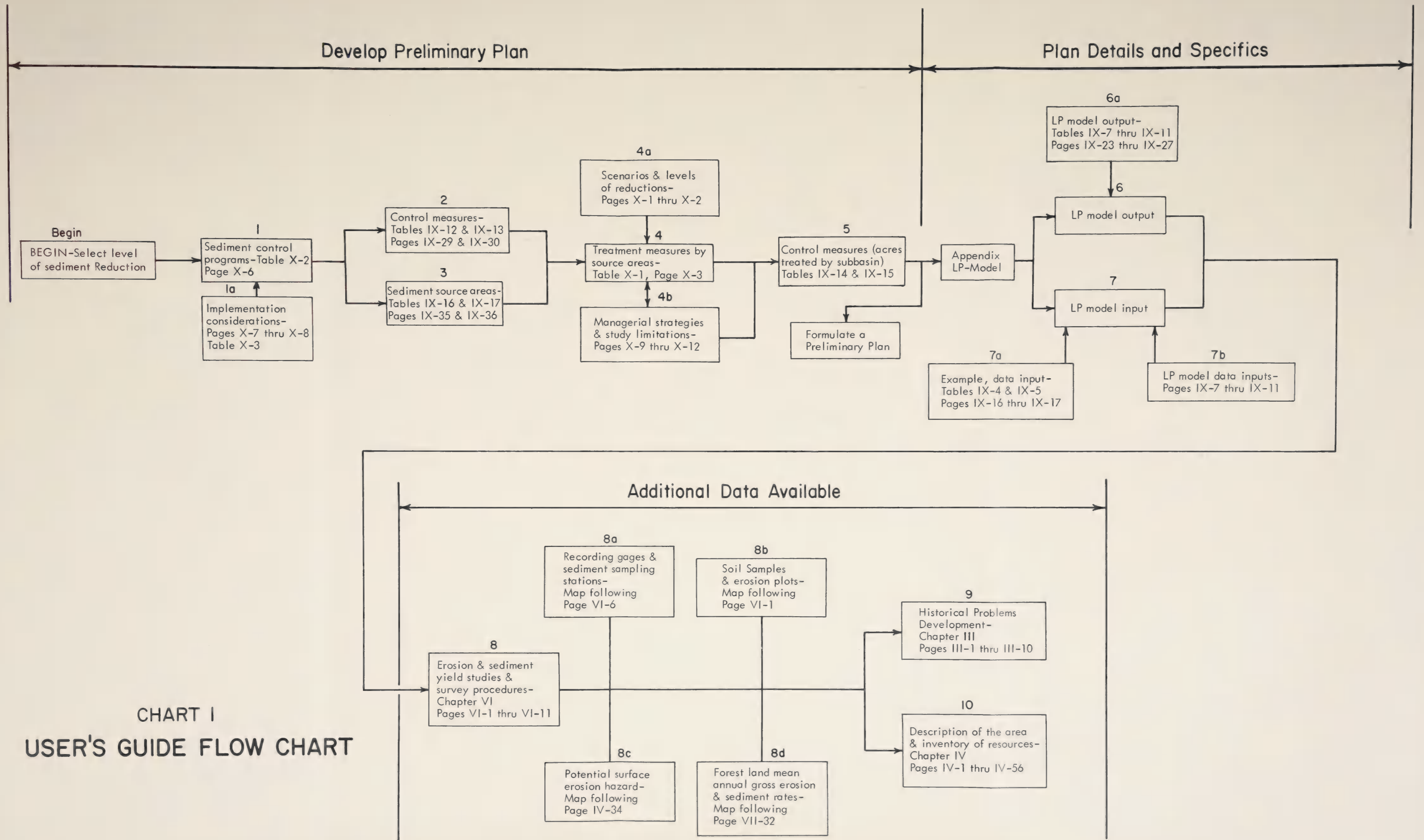
### NOTE: USER ASSISTANCE

For answers to specific questions concerning this report contact:

USDA River Basin Planning Staff  
1220 S.W. Third Ave.--16th Floor  
Portland, Oregon, 97204  
Telephone (503) 221-2797







## CHAPTER III

### HISTORICAL DEVELOPMENT



# HISTORICAL DEVELOPMENTS

## EARLY HISTORY

The settlement of the Tillamook Bay Drainage Basin started in 1851 but had a slower growth pattern than surrounding areas of northwestern Oregon. The area was isolated from the Willamette Valley, Astoria and the middle coast area by rugged topography and nearly impenetrable forests. Families usually came by boat even though access by sea was difficult due to the dangerous bar at the mouth of Tillamook Bay. Many settlers managed to bring small herds of dairy cattle. By 1853, enough families had arrived to settle in Tillamook, Nestucca and Lower Nehalem and they petitioned the State to create Tillamook County. Their petition was considered, and on December 13, 1853, the State Legislature established the new county from portions of Yamhill and Clatsop Counties.

Access to the outside world (anywhere beyond Tillamook County) continued to be by water but the people could only plan on sporadic trips. Consequently, there were times when Tillamook was without staples and mail for extended periods of time. In addition, their butter would spoil waiting for shipment, giving them no income to purchase supplies. Regular ship service did not begin until 1886. The Trask Toll Road was opened for use in 1871, followed by the Tillamook, Nestucca via Beaver Toll Road in 1883 and the Wilson River Road in 1893. All of these early toll roads were single track, poorly maintained and impassable much of the time. The Wilson River Road was designated as a State highway in 1931 but was not constructed until 1941. The Coast Highway (present day US 101) was also completed about this time.

The railroad was completed to Tillamook in 1911, after which maintenance of the toll roads was discontinued. The people no longer had to depend upon ships for major movement of supplies and produce. The sea was still used by the lumber industry and also to support a sizeable commercial fishing fleet. Construction of the jetties by the U.S. Corps of Engineers began in 1918 and continued as funds became available. The Corps also dredged the channels for a period of time until sediment deposition became so serious as to negate dredging efforts within as little as three months. Fishing activities were curtailed some years ago; the Oregon Fish Commission closed Tillamook Bay to all commercial salmon fishing in 1962. Shipping activities began to decline until only a remnant charter fleet remains along with small pleasure craft. Much of the Tillamook fish catch is now landed at other ports. Canneries have closed, and shipping vessels no longer call at Tillamook ports. Logs, lumber, and cheese now leave the Tillamook area by truck or rail.

## RESOURCE USES

Early settlers cleared the land of large spruce, hemlock, cedar and fir trees and used the lush vegetation of white clover to feed their dairy herds. The sale of butter and, to a lesser extent, milk was their livelihood. The original cows were a mixed breed including California longhorns. Now, the area has some of the most productive dairies with the finest herds of Holstein, Jersey, Guernsey and Ayrshire cows in the country.

Butter production was a risky business enterprise due to the difficulty of making shipments by sea or on poor roads. Finally, around the turn of the century, the art of cheese making was introduced. The rich milk from the cows in the basin resulted in a cheese which has become famous across the country. Individual farmers made and marketed their own cheeses until the Tillamook Creamery Association was formed in 1909. Uniform quality control was achieved by 1969. In 1971, the Association received from its members 156 million pounds of milk for processing. From that amount, 111 million pounds were used to process about 12 million pounds of Tillamook Cheese. There is a great demand today for the flavorful cheese from Tillamook.

Logging and lumber production started in the late 1860's. The work was done by hand using axes, crosscut saws, jack screws and peavies. It was necessary to work in close proximity to rivers and streams since the logs were rolled into the water by hand and floated to the mill. When oxen and skid trails were added to the logging process, it was possible to harvest logs farther away from the river bank. A crew of six men and 8 oxen moved 30-40 logs in a single day while now, a crew of four is expected to move 400-600 logs in a day. The donkey engine replaced the oxen about the turn of the century. Railroad spurs were extended inland and the industry began to pick up the pace. In 1923, twenty sawmills were operating in the county and an estimated 15 billion board feet of timber was produced in the Tillamook Bay drainage basin. This did not include weed species such as red alder.

Timber harvests were subject to considerable seasonal fluctuations but managed to maintain a steady growth from 1875 to 1922. Production increased to about 150 million board feet annually with 75 percent of the logs going to mills outside of Tillamook County.

After the devastating Tillamook forest fires, the salvage of fire-killed timber resulted in a rapid increase in the timber harvest starting in 1940 and peaking at about 610 million board feet in 1952. Harvest then began a decline until 1957 at which time it leveled out at about 255 million board feet. This level has continued into the 1970's but the average annual cut is projected to decrease to about 77 million board feet from 1980 to the year 2000.

Lumber production for the period 1875 to 1922 reached an annual level of about 35 million board feet and then remained fairly steady until 1945. Mill activity increased due to salvage of fire-killed timber. By the late 1960's, the average annual lumber production was about 140 million board feet. There were 19 mills in the county in 1948 but most of them were phased out following a decline in salvage operations. Production from the three presently existing saw mills now averages about 160 million board feet annually.

The fishing industry developed slowly in Tillamook because the bar at the mouth of the estuary was considered to be the most dangerous to cross of all the bars on the Oregon coast. Ship owners were unwilling to establish regular schedules and even more reluctant to locate there on a permanent basis. The fish which were harvested off the coast in the Tillamook area were often unloaded for processing at other ports such as Astoria.

Harbor improvement, jetty construction and dredging which took place after 1918 permitted development of a good fishery for a short period of time. The catch included salmon, crabs and other shellfish and bottom fish. However, the fishing industry was greatly affected and began to decline with the advent of the many forest fires in the upper basin area. Severe erosion problems developed and thousands of tons of soil washed into the stream systems. A substantial amount of soil ended up in the bay. Channels were blocked, eelgrass beds smothered and shellfish beds destroyed. By 1919, the channel between Tillamook and Bay City had been abandoned and, by 1925, the channel above Bay City was also lost to deep draft vessels. Since dredging operations were often negated by sediment deposition in less than three months after completion, (the normal effective period of time for a dredging operation is considered to be three years), the conclusion was reached that it was too costly to maintain a dredged channel the entire length of the bay. The U.S. Corps of Engineers then curtailed dredging operations, thus bringing to an end lumber ships calling at the port of Tillamook.

A reduced fishing industry continues to operate out of Tillamook Bay. The principal source of income is from oysters, crabs and a chum salmon hatchery-cannery development. Commercial oyster production has continued in the bay despite the problems created by sediment. More than 85 percent of Oregon's oyster production comes from Tillamook Bay. Approximately 80,000 pounds of meat was shucked from oyster beds in 1968. About 2,600 acres of tidelands in the bay are leased to oyster producers. These growers have curtailed operations to only 500 acres at the present time because of the difficulty of seeding the oysters and protecting them from siltation. The ocean fishery is composed mostly of small sports fishing craft which can negotiate the bar, a few commercial operators with shallow-draft boats, and boats from other ports.

When the railroad was completed in 1911, development accelerated. The recreation-oriented community of Bayocean had been started, and by 1915, fifteen hundred lots had been sold and construction of summer homes began. A natatorium was constructed on Bayocean Peninsula and deep sea fishing became a sport. The entire development has long since disappeared, having been washed away by erosion of the shores of the sand spit which forms the peninsula.

Sports fishing, unlike commercial fishing did survive and grow in spite of the sediment problems. Boat access is more difficult and the size of the boats is limited by bar conditions. The Oregon Fish Commission made a study of sports fishing in Tillamook Bay in 1971 and found that there were 66,500 person days devoted to recreational fishing annually. These people spent a total of 172,300 hours harvesting the different varieties of fish and shellfish. (See Table III-1).

The five river systems are also important fisheries. There were 102,600 angler days spent on the rivers in 1976 to catch 27,275 anadromous fish. The total sports fishery catch by river and angler days is summarized on Table III-2.

Hunting has also become popular in the basin. The Tillamook Burn has developed into an ideal habitat for deer and elk. Portland area hunters utilize the area in ever increasing numbers.

Another growing recreational activity in the basin is motorcycle riding on the many trails and roads particularly in the Tillamook Burn. Many cycle clubs from the Willamette Valley have competitive meets or cycle roundups there. It is not uncommon for several hundred cycle riders to be in the upper Wilson River area on a given weekend. This is especially true following a summer rainstorm.

Studies conducted by both Tillamook County and Oregon recreation planners indicate that recreation use in the Tillamook Bay Drainage Basin is growing faster than the population growth of the State. Demands for recreation may soon outstrip available resources. The sediment and erosion problems tend to aggravate the situation.

Table III-1--NUMBER OF ANGLER TRIPS, HOURS OF EFFORT, AND ANIMALS CAUGHT  
TILLAMOOK BAY, BY MONTH  
MARCH 1 THROUGH OCTOBER 31, 1971

Fishery	Month	No. Angler Trips	Angler Hours	Catch				Total
				Finfish	Crabs	Clams	Misc. Invert.	
Boat	March	669	2,243	3	2,387	0	0	2,390
	April	1,162	3,973	2	3,043	0	2	3,047
	May	1,874	7,045	104	4,174	0	0	4,278
	June	1,411	4,795	247	3,095	0	0	3,342
	July	2,045	6,393	293	5,170	0	0	5,463
	August	3,383	11,740	226	5,479	0	0	5,705
	September	7,245	31,267	808	5,700	0	0	6,508
	October	6,693	31,020	945	3,274	0	0	4,219
	Total	24,482	98,476	2,628	32,322	0	2	34,952
	March	673	1,333	511	26	0	0	537
Shore	April	1,280	2,638	1,295	30	0	0	1,325
	May	3,122	6,477	5,363	126	0	0	5,489
	June	2,000	4,151	3,175	56	0	0	3,231
	July	3,724	7,555	3,452	147	0	0	3,599
	August	3,368	6,790	2,689	14	0	0	2,703
	September	1,858	3,766	773	0	0	0	773
	October	1,410	2,867	296	0	0	0	296
	Total	17,525	35,577	17,554	399	0	0	17,953
Tide flat	March	3,745	5,202	26	18	93,900	5,600	99,544 <sup>1</sup>
	April	3,025	4,653	21	15	75,900	4,500	80,436
	May	4,990	6,453	22	16	80,100	4,800	84,938
	June	4,194	6,453	29	21	105,200	6,200	111,450
	July	5,611	9,351	39	27	140,700	8,400	149,166
	August	3,643	6,071	25	18	91,400	5,400	96,843
	September	1,031	1,494	7	5	25,900	1,500	27,412
	October	28	41	0	0	700	40	740
	Total	24,471	38,255	169	120	613,800	36,440	650,529
	March	5,087	8,778	540	2,431	93,900	5,600	102,471
Combined	April	5,467	11,264	1,318	3,088	75,900	4,502	84,808
	May	8,190	18,512	5,489	4,316	80,100	4,800	94,705
	June	7,695	15,399	3,451	3,172	105,200	6,200	118,023
	July	11,380	23,299	3,784	5,344	140,700	8,400	158,228
	August	10,394	24,601	2,940	5,511	91,400	5,400	105,251
	September	10,134	36,527	1,588	5,705	25,900	1,500	34,693
	October	8,131	33,928	1,241	3,274	700	40	5,255
	Total	66,478	172,308	20,351	32,841	613,800	36,442	703,434
Grand Total								

<sup>1</sup>/Catch data for the tideflat fishery determined by multiplying the average catch per year times the number of angler trips per month.

Source: Oregon Fish Commission, 1971

Table III-2, Tillamook Bay River System Fishery Data, 1970

Water	Angler Days	Sports Species	Harvest Number
Wilson R.	800	Spring (chs)	200
		Chinook	
	4,400	Fall (chf)	1,100
		Chinook	
	2,800	Coho (Co)	200
	44,800	Winter (stw)	11,200
		Steelhead	
	2,000	Summer (sts)	500
Trask R.		Steelhead	
	2,500	Searun (cts)	1,250
		Cut Throat	
	1,400	Chs	350
	7,700	Chf	1,925
	4,900	Co	1,225
	14,800	Stw	3,700
	- -	Sts	- -
Kilchis	2,500	Cts	1,250
	240	Chs	60
	1,320	Chf	330
	840	Co	210
	4,000	Stw	1,000
	- -	Sts	- -
	1,500	Cts	750
Miami R.	40	Chs	10
	240	Chf	60
	120	Co	30
	900	Stw	225
	- -	Sts	- -
	1,000	Cts	500
Tillamook R.	240	Chs	60
	1,320	Chf	330
	840	Co	210
	400	Stw	100
	- -	Sts	- -
	1,000	Cts	500
Total			27,275

Source: Oregon Fish Commission 1970

## MAJOR BURNS

Fires have always been a part of the ecological development of Tillamook Basin. The early burns did not have the devastating effect as did the fires in the twentieth century. One of the reasons recent fires have been so serious is the tendency for recurrence of severe burns over the same area within a short time interval. The first of the recent fires was in 1918, burning part of the upper Kilchis and North Fork Wilson River drainages (see Tillamook Burns Map). A larger fire occurred in 1933 which not only reburned most of the 1918 fire area, but also burned the remainder of the upper Kilchis, Wilson and Trask Rivers, covering a total area of 240,000 acres. Much of this same area burned again in 1939 covering 190,000 acres, and then again in 1945 when fire covered 180,000 acres. The concerned people of Tillamook and the State of Oregon launched a massive reforestation and fire control program in 1949 (completed in 1973). Sixty-one percent of the burned area has been reforested, 220 miles of fire breaks constructed, and 1½ million snags felled. So, when a fire occurred in 1951, it was stopped after burning only 20,000 acres. Altogether the fires, including the 1951 fire, covered a total of 355,000 acres with 228,600 acres occurring in the Tillamook Bay Drainage Basin. A loss of approximately 11 billion board feet occurred in the basin. Salvage operations recovered 4.5 billion board feet so that the net loss was about 6.5 billion board feet.

The effects of forest fires go beyond the loss of timber, forage and wildlife. Sediment deposition, streambank cutting and flooding are usually the aftermath of large burns.

The economy of Tillamook suffered both direct and indirect consequences from the fires. An estimated 10 million board feet of lumber was destroyed during one of these fires (1933). The County could not meet its State tax commitments, much less finance its own operations. Many companies and individuals were unable to keep their land so it was turned back to the County in lieu of taxes and eventually deeded to the State so that reforestation could be undertaken by the State Forester. Planting and seeding began on 22,000 acres through a County, State and Federal cooperative effort. Other groups, such as the Isaac Walton League, 4-H Clubs and schools also helped during the reforestation project.

The fires and salvage logging left thousands of acres bare to the coastal storms. Erosion processes were accelerated and thousands of tons of sediment were washed into the streams to eventually be deposited in the bay. Although the amount of sediment reaching the bay has been reduced since the reforestation program became effective, there is still a need for continued reduction in the amount of sediment entering the streams and estuarine systems.

To summarize, as a result of the fires, Tillamook Basin has lost an estimated \$1,787 million in timber. The loss of fisheries, wildlife, and aesthetics is immeasurable. This estimation is over simplified, and the true losses are greater today than the \$1,787 million because of economic multipliers and interest accrued on dollars earned. The fact remains that Tillamook suffered a tremendous financial loss.

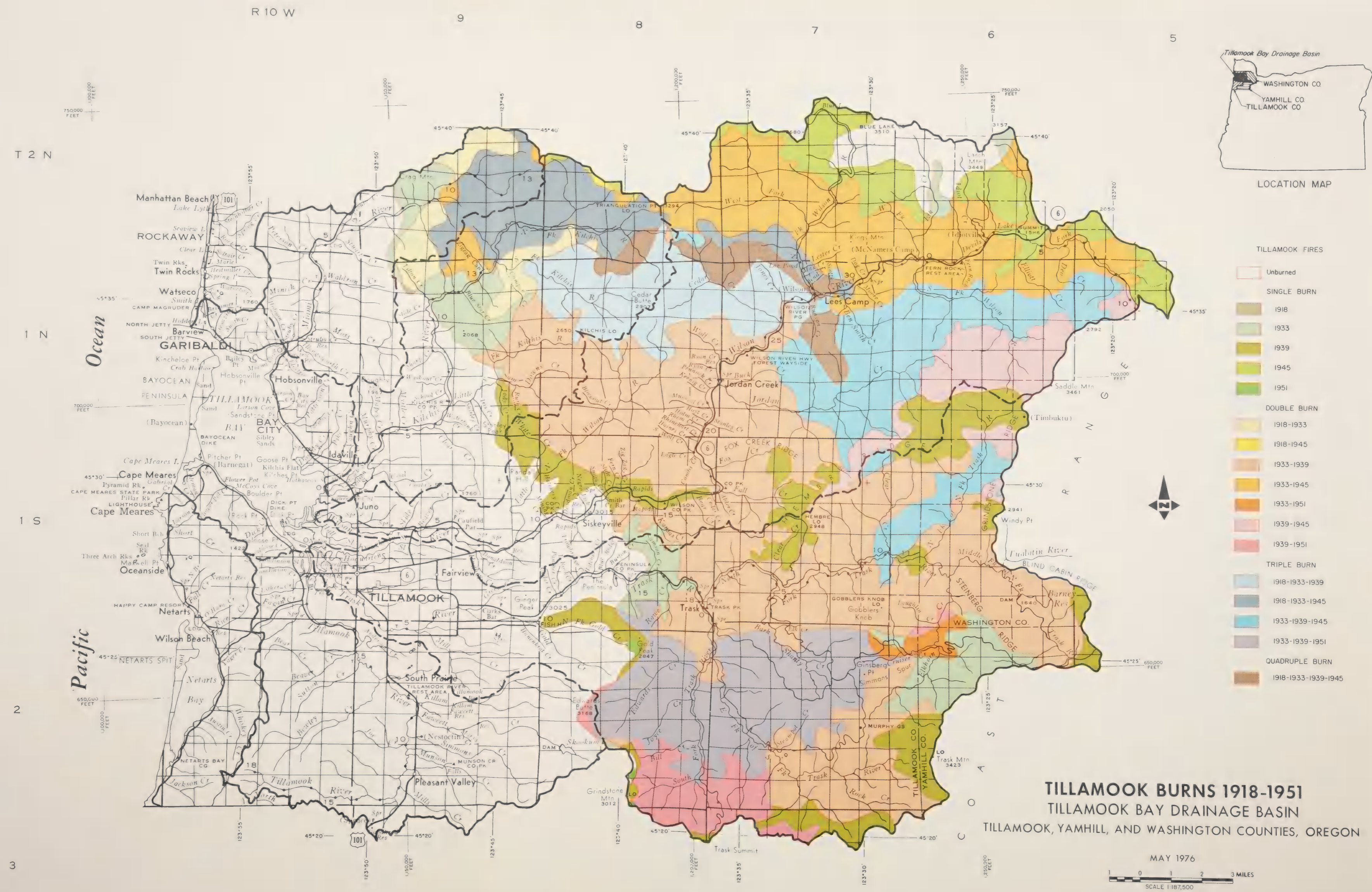
## SEDIMENT IN THE BAY

Modern deposition and erosion of river-borne sediments in Tillamook Bay Estuary began about 9000 years before present (B.P.) when worldwide rising ocean levels entered the river valleys which had been formed by earlier ocean fluctuations.

Extensive farming, logging operations, and numerous fires destroyed large areas of timber and protective ground cover in the upper watershed resulting in a drastic increase in erosion and sediment production. This source of sediment, in conjunction with the almost annual occurrence of overbank flooding and streambank cutting during periods of high water, produced conditions detrimental to the survival of aquatic life and industrial development in the bay area.

The bay is separated from the ocean by Bayocean Peninsula, a four-mile long sand spit varying in width from 1,000 feet to over 3,000 feet at the north end. Once a body of deep water with a fairly uniform depth, sediment deposition and delta expansion at the north and south end of the bay has caused it to become progressively more shallow. Deposition in the northwest section of the bay is likely due in part to the migration of beach sands through the 1200foot wide channel entrance as a result of tidal action. Construction of the rock jetties a number of years ago may have resulted in accelerated shoreline erosion and consequent deposition of sediment within the confines of the channel. This occurrence has resulted in the formation of shoals --a definite navigation hazard. Other contributing sources of sediment to the Bay area include the (1) wind transport of intertidal sands due to shore-line erosion, (2) spoil from landslides which is dumped along the highway on Tillamook Bay intertidal lands, and (3) sediment-laden streams draining into the bay.

In geologic terms, the youngest part of the modern fill is accumulating in the bay at the present time. The radiocarbon dating technique used on the detrital wood that forms the bulk of datable materials does not provide ages for the very youngest deposits. At a depth of 22.6 feet mean sea level (MSL), the age of the fill is 3,300  $\pm$  200 years before present (B.P.). No datable younger materials from shallow depths were found anywhere in Tillamook Bay. Available stratigraphic data suggests deep or quiet water deposition for sediments in





the lower and middle part of the modern fill. Deep water implies that the sea level may have been considerably above the sediment deposition surface during the early and middle periods of bay filling.

## PAST ECONOMIC EFFECTS

Economic development of Tillamook Bay Drainage Basin has historically centered around the timber and lumber industries. Dairy-ing, tourism, and commercial fishing are also important sectors of the local economy. The wood products and related industries accounted for nearly 50 percent of the total value of county exports in 1973.

Lumber was first exported from the area by boat around the early 1880's. Sediment has long since choked the main shipping channel to the town of Tillamook, preventing water-borne export of logs and wood products. However, the economic effects are difficult to determine since exports of lumber and wood products continued via other means. In recent years, rail and truck shipments have replaced water-borne traffic. It could be argued that the major fires have likely had a greater effect on the timber industry than has sediment deposition in the bay. An estimated 13 billion board feet of timber was destroyed by those fires. <sup>1/</sup>

The seafood industries and commercial fishing activities have suffered as a result of sediment accumulation in the bay. Commercial fishing used to be more important to the local economy than it is at the present time. From 1923-1947 the average annual catch of all species was about 1,543,000 pounds. The annual catch has decreased to 608,000 pounds from 1948-1956, and during the years 1957-1961, the average annual catch was only 101,000 pounds.(Oakley, Arthur L.) In 1962, the Oregon Fish Commission closed Tillamook Bay to all commercial Salmon fishing.

Severe economic reverses have been experienced by the commercial fishing industry. However, it is debatable as to how much of this hardship can be blamed on sediment since other coastal commercial fisheries on the Columbia River and as far north as British Columbia experienced downtrends during the same time periods.

Sediment has seriously affected recreational boating. With a high risk of getting stranded on sand bars in Tillamook Bay Estuary, recreational boaters have an incentive to look elsewhere for weekend boating activities.

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<sup>1/</sup> See preceding section, Major Burns.

It is impossible to determine the historical economic effects of erosion and sediment on recreational activities. However, during the early 1900's, money was being invested at Bayocean City to develop a summer recreation resort. Erosion of the shores of the Bayocean Peninsula eventually resulted in the disappearance of the entire development, which thus had a direct damaging historical effect on the recreation industry.

While the economic impacts of sediment are often difficult to determine, such is not the case when it comes to dredging. The U.S. Corps of Engineers has been involved in the bay since 1888 and, since 1922, primarily with dredging.<sup>1/</sup> In 1888, the Corps built dikes in Hoquarton Slough near the town of Tillamook. Ocean-going ships were able to navigate the length of the bay loaded with lumber. By 1919, the channel between Tillamook and Bay City had been abandoned, and by 1925 the channel above Bay City was also lost to deep draft vessels. Several studies were conducted by the Corps from 1897 to 1941, with the conclusion that it was too costly to maintain a dredged channel the length of the bay.

In recent years, the Corps has attempted to maintain the Garibaldi boat basin and a channel from the basin out past the bar to the ocean. However, even with the dredging program, navigational channels continue to fill with sediment. Often a dredging job will be effective for only three months. Historically, increased sediment in the bay has resulted in decreased use of the bay by boats, both commercial and non-commercial. With this decrease in use, the Corps finds less economic justification for dredging. Tillamook Bay is low on the dredging priority list, especially compared to the Columbia River and Coos Bay. Decreased dredging, in turn, results in decreased boating, completing the cycle.

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<sup>1/</sup> From the U.S. Corps of Engineers open files.

## CHAPTER IV

### EXISTING LAND & WATER RESOURCES



# EXISTING LAND & WATER RESOURCES

## RESOURCE INVENTORY SUMMARY BASE YEAR (1975)

The quantity and quality of the resources in Tillamook Basin in the base year (1975) were, in large part, the result of man's influence on the basin. Much of the flat land in the valley bottoms and around the bay was cleared of trees to permit development and to provide pasture and hay for the dairy herds. Timber harvest provided additional income, but this resource was frequently affected by fires. A massive reforestation program was undertaken but even with this effort, large quantities of sediment have moved into the streams and bay affecting the fishery resources. The construction of roads improved access and allowed the development of the area as a recreation resource. Table IV-1 refers to land use by acres for each of the five drainage basins within the Tillamook study area for the base year (1975).

LAND USE VS. DRAINAGE  
TILLAMOOK BAY DRAINAGE BASIN - 1975

Table IV-1

Land Use	Tillamook Ac.	Miami Ac.	Kilchis Ac.	Wilson Ac.	Trask Ac.	Sub-Total Ac.	Total Ac.
<b>Forest Lands <sup>1/</sup></b>							
1. Clearcuts, low brush and seedlings	6,120	4,370	1,530	930	660	13,610	
2. Burns including low brush and seedlings	- -	700	7,410	16,370	20,500	44,980	
3. Old-growth	1,290	1,490	2,630	15,010	10,140	30,560	
4. Mature second growth	4,530	3,130	4,830	15,580	8,180	34,250	
5. Pole timber	11,920	5,500	9,390	27,960	18,060	72,830	
6. Saplings	3,930	2,230	3,820	12,960	16,090	39,030	
7. Tall brush and seedlings	3,010	2,330	4,030	11,590	12,540	33,500	
8. Hardwoods	2,680	4,520	9,140	20,050	14,470	50,860	
9. Forested pasture	1,640	220	460	400	710	3,430	
Subtotal	35,120	24,490	43,240	118,850	101,350	323,050	323,050
<b>Agricultural Lands <sup>1/</sup></b>							
1. Irrigated pasture	120	200	460	1,120	1,820	3,720	
2. Other wet pasture	960	-	-	-	-	960	
3. Dry pasture unimproved	1,240	170	470	480	1,660	4,020	
4. Dry pasture improved	4,370	360	1,620	1,790	5,330	13,470	
5. Brush pasture	570	90	210	190	310	1,370	
Subtotal	7,260	820	2,760	3,580	9,120	23,540	23,540
<b>Water <sup>2/</sup></b>							
1. Rivers	280	70	280	600	600	1,830	
2. Bays	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	9,150	
Subtotal	280	70	280	600	10,980	10,980	10,980
<b>Rock and Sand</b>							
1. Other lands	40	- -	500	2,380	1,110	4,030	
2. Bay	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	190	
Urban	440	170	140	130	850	1,730	1,730
TOTAL	43,140	25,550	46,920	125,540	113,030	- -	363,520

<sup>1/</sup> Road and trail rights-of-way are also included in each acreage of this table.  
A more detailed analysis follows.

<sup>2/</sup> Water listed above includes only streams wider than 10 feet and water bodies four acres or larger in size.

Source of Data: USDA staff using the PIXSYS Program at Oregon State University

## TOPOGRAPHY AND GEOLOGY

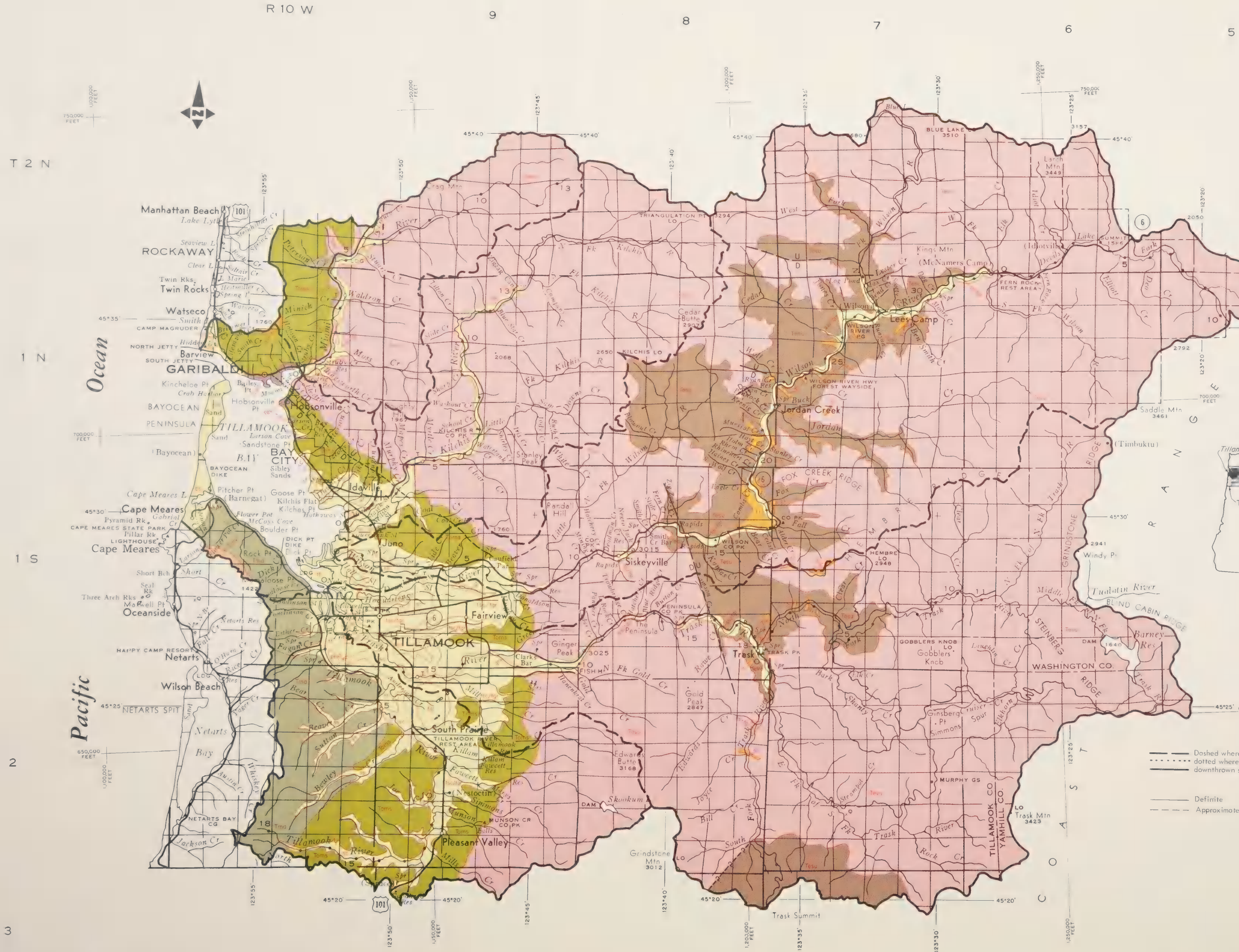
The study area extends to the west from the sharp crestline of the Coast Range followed by gentle to steeply sloping rocky uplands, deeply incised canyons, and a flat to gently rolling floodplain. The western extremity of the area includes a coastline largely of sand dunes, beach sand and sedimentary rock alternating with an occasional rugged headland of volcanic rock. Most of the present upland topography is the result of downcutting and degradation by the tributary streams resulting in the formation of a dendritic and radial pattern.

Elevations along the summit vary from 600 feet to 3461 feet, averaging about 1500 feet. Well known peaks or ridges include Larch Mountain, 3449 feet; Hembre Ridge, 3409 feet; Kings Mountain, 3226 feet; Trask Mountain, 3423 feet; and Grindstone Mountain, 3012 feet. Major streams draining into Tillamook Bay include the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Notable tributary streams include the Elk, Drift, Jordan, and Fox Creeks on the Wilson River, the North, East and South Forks of the Trask River, and Edwards and Bark Shanks Creeks, all tributaries to the Trask River system.

The crust of the earth in northwestern Oregon appears to be very thin, probably not exceeding 10 miles in thickness in places. Resistivity studies indicate that it is primarily oceanic in character. Recent theories of plate tectonics suggest that it may represent Eocene sea floor that has been welded to the continent. There may be no older rocks than Eocene in the subsurface part of the area.

Structurally, the core of the Oregon Coast Mountain Range is interpreted to be a broad uplift which is generally described as a north-plunging geanticline. The oldest rocks in the basin, the Tillamook volcanics of lower Eocene age, cap the ridges with older sedimentary rocks being exposed in the canyon areas. Also, in the middle reaches of Wilson and Trask River drainages, a fault is indicated between exposures of lower Eocene volcanic rock on the west and exposures of undifferentiated Eocene sedimentary rocks to the east. Available attitudes and abrupt changes in lithology across the fault tend to rule out simple faulting or facies change. In addition, the north-south alignment of the middle reaches of the Wilson and Trask Rivers may indicate a north-south structural break in the Eocene terrain of this area (see Generalized Geology Map - following page IV-4).

Lithologically, indurated rock units ranging in age from Eocene through Pliocene and unconsolidated deposits of Pleistocene to Recent age, underlie the floodplain area and structurally from the steeper slopes of the basin. The consolidated units total over 20,000 feet in thickness and include submarine and subaerial dark gray to black lava flows, flow breccia and some tuffaceous marine sedimentary rock; marine siltstone, claystone and sandstone; intrusive igneous rock; marine terrace deposits; and fluvial and tidal flat deposits. Rocks units shown on the geology map included in this chapter are undifferentiated Eocene sedimentary rocks, undifferentiated Eocene volcanic rocks and middle to late Miocene basaltic intrusive rock. Unconsolidated deposits of Pleistocene to Recent age characterize the floodplain area through which the five major drainages flow to reach Tillamook Bay. These include marine terraces, terrace alluvium (silty clay to silty sand over gravel), flood-plain alluvium (clay, silty clay, silt, sandy silt and occasional gravel), and peat, active and stable dune sand, beach sand, and tidal flat soils.



GENERALIZED GEOLOGY

UNCONSOLIDATED SURFICIAL UNITS

- FLOOD PLAIN ALLUVIUM
  - tf - tidal flat
  - pt - peat
  - cl - clay
  - sc - silty clay
  - sl - silt
  - ss - sandy silt
  - gr - gravel

- SANDS
  - bs - beach sand
  - ad - active dunes
  - sd - stable dunes

- TERRACE ALLUVIUM
  - tsc - terrace silty clay
  - tgr - terrace gravel

STRATIGRAPHIC UNITS

- MARINE TERRACES

- MIOCENE VOLCANIC ROCKS
  - Localized accumulations of massive basaltic breccia (Onion Peak and Wickup Mountain), basaltic flow rocks (Cape Meares), palagonitic breccias and pillow basalts. The basalts are petrochemically indistinguishable from the Yakima Basalt (Snively, MacLeod and Rau 1969).

- INTRUSIVE ROCKS

- Primarily middle to late Miocene basaltic intrusive rock, which includes thick sills (Green Mountain and Tillamook Head), dikes, ring dikes, sills, podlike bodies (Nashkahmie Mountain (T)) and complex masses of small dikes and intruded sedimentary rocks (Tic), partly of late Eocene age in the Hebo quadrangle.

- ASTORIA FORMATION

- Approximately 2,000 feet of consolidated to semi-consolidated, thick-bedded to thin-bedded, medium grained, buff, micaceous, arkosic sandstone and interbedded siltstone.

- OLIGOCENE TO MIOCENE SEDIMENTARY ROCKS

- Over 5,000 feet of thin-bedded to massive, medium-gray to dark-gray, tuffaceous siltstone and claystone with subordinate amounts of sandstone and shale locally. Basaltic sandstone and conglomerate are present at the base of the section in places.

- UNDIFFERENTIATED EOCENE VOLCANIC ROCKS

- Several thousand feet of chloritized basalt flows and basalt breccias of submarine and subaerial origin. Zeolites are common locally. Equivalent primarily to the Nestucca Volcanics of Snively and others (1949).

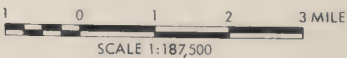
- UNDIFFERENTIATED EOCENE SEDIMENTARY ROCK

- Several thousand feet of undifferentiated, thin bedded to indistinctly bedded, tuffaceous, volcaniclastic siltstone, clay siltstone, and sandstone. The sedimentary rock occurs stratigraphically between the three Eocene volcanic units and grades laterally into them locally. Volcanic interbeds are present in places.

GENERALIZED GEOLOGY

TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,  
OREGON

FEBRUARY 1976





# CLIMATE

## GENERAL

Tillamook Bay Drainage Basin is bordered on the west by the Pacific Ocean. Close proximity to the ocean gives the area a marine climate. Most large air masses moving across the area originate many miles at sea, often taking many days to reach the coast. In time, the air masses become nearly saturated with moisture from the ocean and their temperature approaches that of the ocean. Year-round temperature ranges are relatively small in the immediate coastal area.

There is considerable rain during the late fall, winter, and early spring and the usual amount of fog and low clouds associated with a marine climate. During the winter, ocean-spawned storms frequently move across the region. At this time the ground is much cooler than incoming air from the ocean. Immediately after crossing the coastline, this saturated air is subjected to two cooling processes -- by contact with the much colder land surface over which it is passing, and by lifting in its forced ascent while crossing the Coast Range. This latter process reduces the temperature at a rate of from three degrees to five degrees F. for each 1,000 foot increase in elevation. This cooling condenses a great deal of moisture causing precipitation on the west slopes of the Coast Range to add to the already very substantial storm totals. These combine to make this one of the heaviest rainfall areas in Oregon. Precipitation elevation relationships are displayed on Figure IV-1.

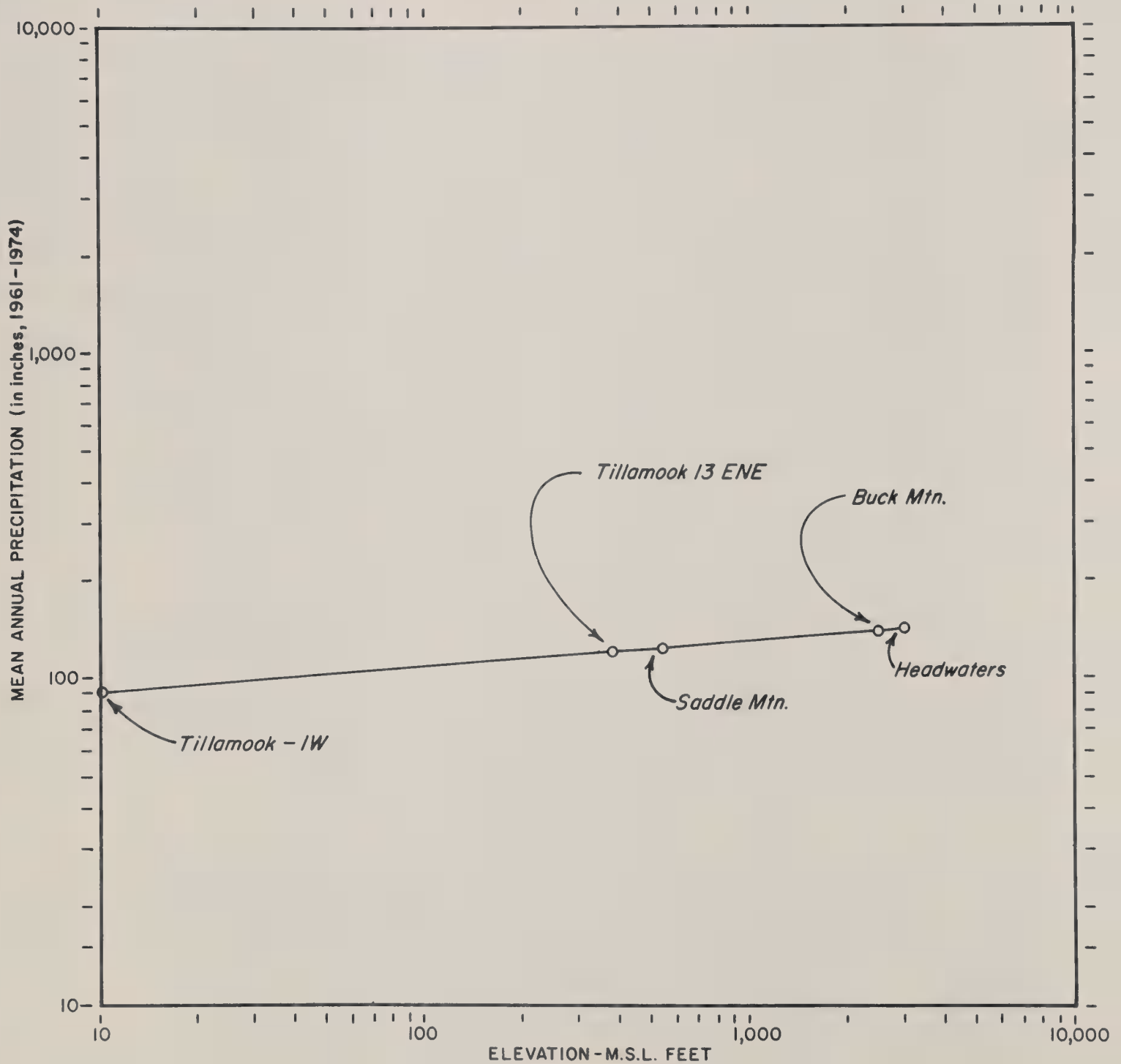
Nearly all the widespread winter precipitation in the area is produced either by a family of mature occlusions or by a quasistationary front with active minor waves. These storms may extend many hundreds of miles to the north or south and are generally three to five days in duration. Tropical cyclones are extremely rare and summer thunderstorms are of local rather than general occurrence. The infrequent hail or sleet storms over the area seldom reach destructive proportions. Mean annual precipitation by months is displayed on Figure IV-2.

Tillamook Basin has a marine-type climate with an average annual temperature of 50 degrees F. There is only about a 15-20 degree difference between the mean January and July temperature in any of the coastal areas, with a tendency for this difference to increase slightly with increase in distance from the ocean. Extremely high or low temperatures are rare. On the average, there are not more than one or two days a year with temperatures of 90 degrees F. or higher in the immediate coastal area and those of zero degrees F. or lower are practically unknown. Moving inland a few miles, the number of days

Figure IV-1

## PRECIPITATION ELEVATION RELATION

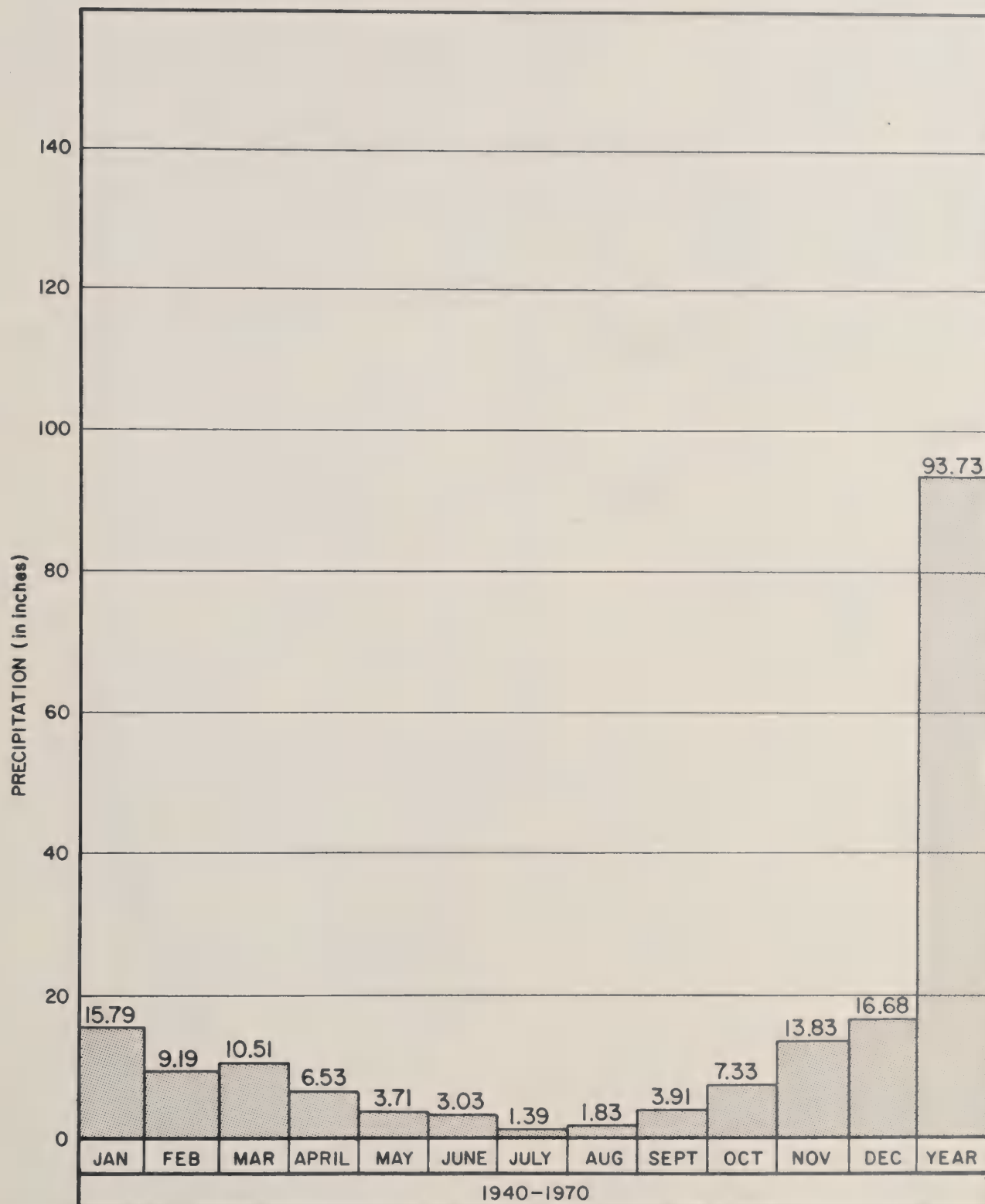
DATA BASE: U.S. WEATHER SERVICE, S.C.S. and O.S.W.R.B.



SOURCE: U.S.D.A. Study Team.

Figure IV-2

# MEAN ANNUAL PRECIPITATION (1940-70) DISTRIBUTION BY MONTHS AT TILLAMOOK, OREGON



SOURCE : Climatology of the United States No. 81 (Oregon) NOAA





**MEAN ANNUAL PRECIPITATION**  
**TILLAMOOK BAY DRAINAGE BASIN**  
**TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES**  
**OREGON**

JUNE 1976  
SCALE 1:87,500  
0 1 2 3 MILES



with 90 degrees F. and above may increase to as many as five a year, but those below zero degrees F. are rare. Days with minimums of 32 degrees F. or less, however, have a long period average of about 20 a year. The warmest average month is July, with 58.9 degrees F. and the coldest is January with 42.5 degrees.

Average annual precipitation ranges from 90 inches to 140 inches in the basin with 84 percent falling between October and May. Summer fog may contribute as much as 26 percent of the precipitation from July through September. Snow is of little significance immediately adjacent to the coast. The annual average is about one to two inches with many years having no measureable amount. Moving inland this gradually increases. The increase is sharply accentuated by increases in elevation. A few miles inland, annual total snowfalls may range from 5 to 20 inches. Density of the mountain snowpack increases from about 25 percent water equivalent in early winter to about 45 percent in April. The mean annual precipitation map in this report is an isohyetal map based on data from the U.S. Weather Service River Forecast Center, Portland, Oregon, using climatological data (1930-57) and information derived from correlations with physiographic factors.

The abundance of fresh marine air continually moving into the coastal area, together with the small daily temperature ranges, results in little seasonal or diurnal range in relative humidity. There is only about 20 percent difference between the long-period average of nearly 90 percent in the early morning, when it is the highest, and about 70 percent in the warmest part of the day, when the relative humidity tends to be lowest.

Despite relatively cool temperatures and fairly high humidity, there is an average April and October total evaporation of 20-25 inches as measured in Class A evaporation pans. The evapotranspiration averages as computed by the Palmer-Havens application to the Thornthwaite method is for a potential evapotranspiration of 25 inches annually. The computed actual value for soils with a two-inch water holding capacity is 18-20 inches and for those of a six-inch water holding capacity it is 20-24 inches.

This area, more than any other in the region, is exposed directly to the major winter storms that frequently move on to the Oregon-Washington coast, often with quite violent winds. Although only a limited amount of recorded wind information is available for the area, it seems reasonable to assume that winds with speeds of 60-70 mph occur almost every winter and those exceeding 100 mph have been recorded on at least four or five occasions in the last 65 years. The prevailing direction on an annual basis is generally westerly with the southerly or southwesterly component greatest in winter and the northwesterly component predominating in summer.

## WATER YIELD

Forested land mean annual water yield as streamflow ranges from 7.5 to 8.6 feet per acre per year, with the greater amounts coming from the steep, higher elevation lands in the Basin.

Figures IV-3 and IV-4 are synthesized hydrographs of the 11 major sub-basins based on correlation with the long-term USGS gage on the Wilson River. The runoff map of the basin is based on Figure IV-5.

The mean annual water yield as streamflow from the forested lands in the Tillamook Estuary Basin amounts to 2,628,296 acre feet. This yield is distributed by subbasins as shown in Table IV-2.

Table IV-2 - WATER YIELD BY SUBBASINS

<u>River Subbasin</u>	<u>Water Yield</u> <u>Acre Feet</u>	<u>Percent</u>
Tillamook	251,775	9.6
Miami	196,263	7.4
Upper Kilchis	178,262	6.8
Lower Kilchis	112,575	4.2
South Fork Kilchis	54,727	2.0
Lower Wilson	397,507	15.2
Upper Wilson	493,843	18.9
North Fork Wilson	131,440	5.0
Main Trask	541,380	5.0
East Fork Trask	156,854	5.9
South Fork Trask	113,170	4.0
TOTAL	2,628,296	100.0

Figures IV-6, IV-7, IV-8 and IV-9 are graphical presentations of the hydrology of the Wilson River at the USGS stream flow gaging station.

Tables IV-3 and IV-4 relate to dependable yield and monthly mean discharge rates, using the Wilson River as an example.

Table IV-5 is a summary by individual drainage of acreages classified according to their hydrologic response.

Figure IV-3

# MEAN ANNUAL HYDROGRAPHS

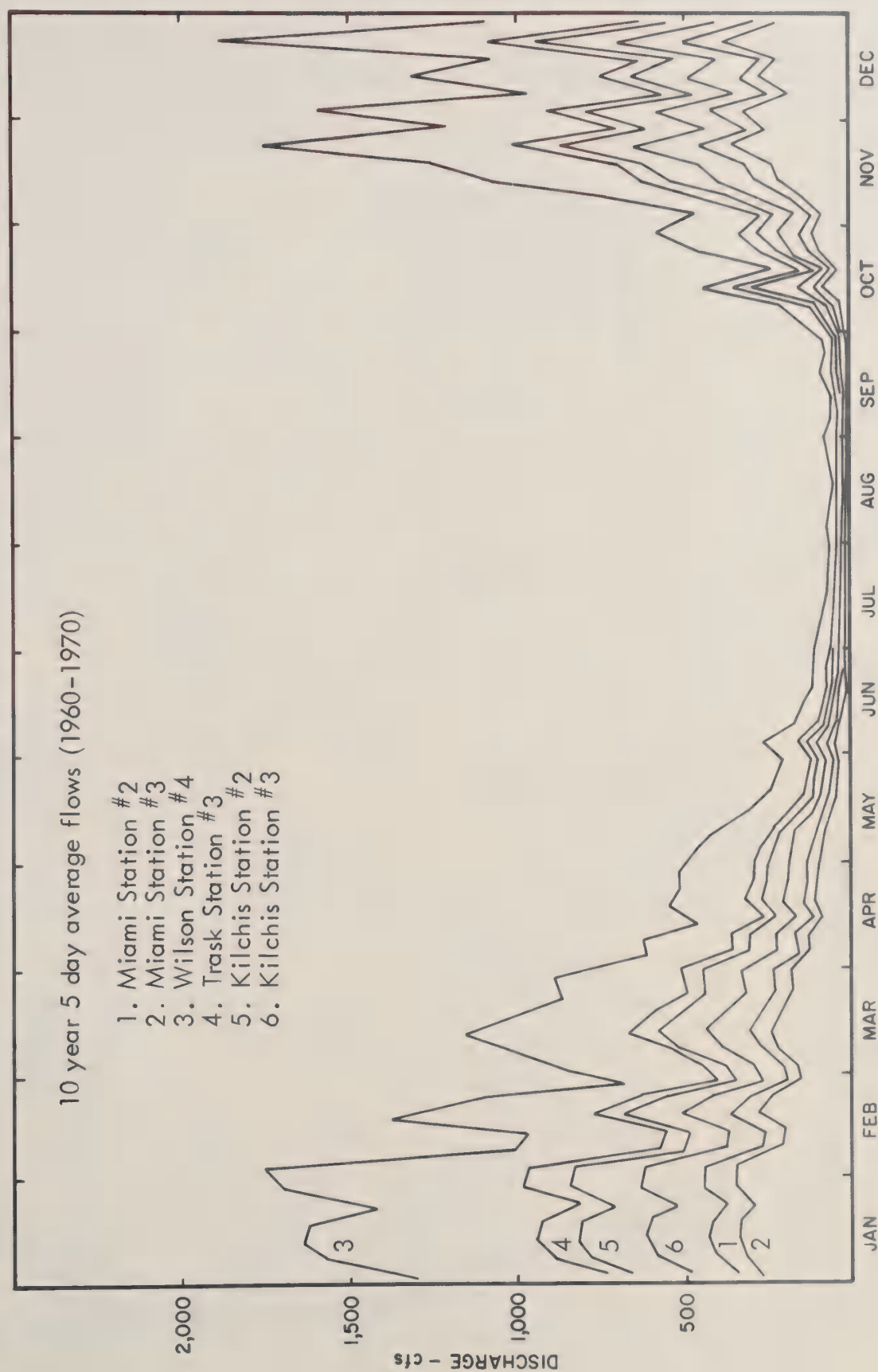


Figure IV-4

## MEAN ANNUAL HYDROGRAPHS

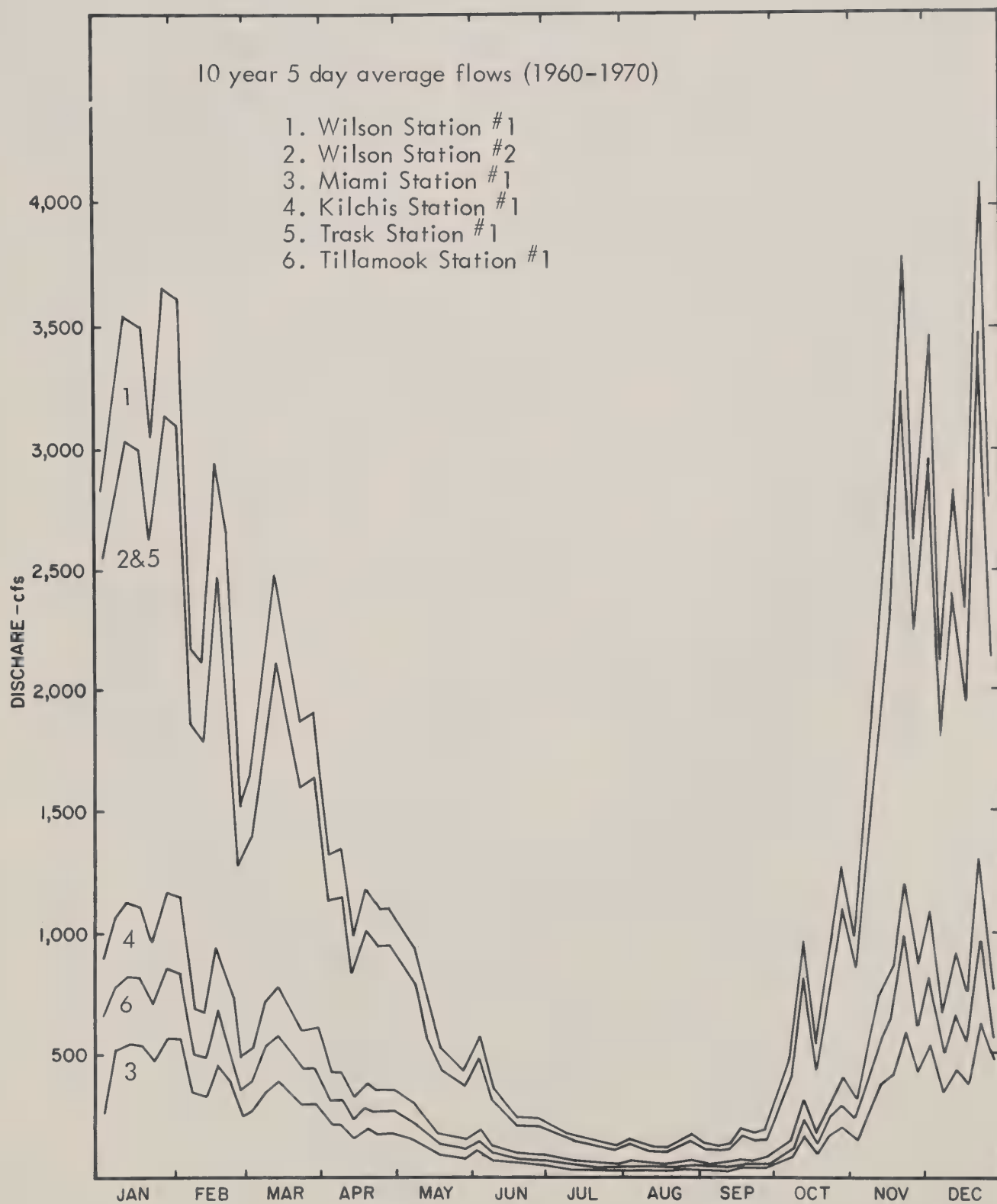
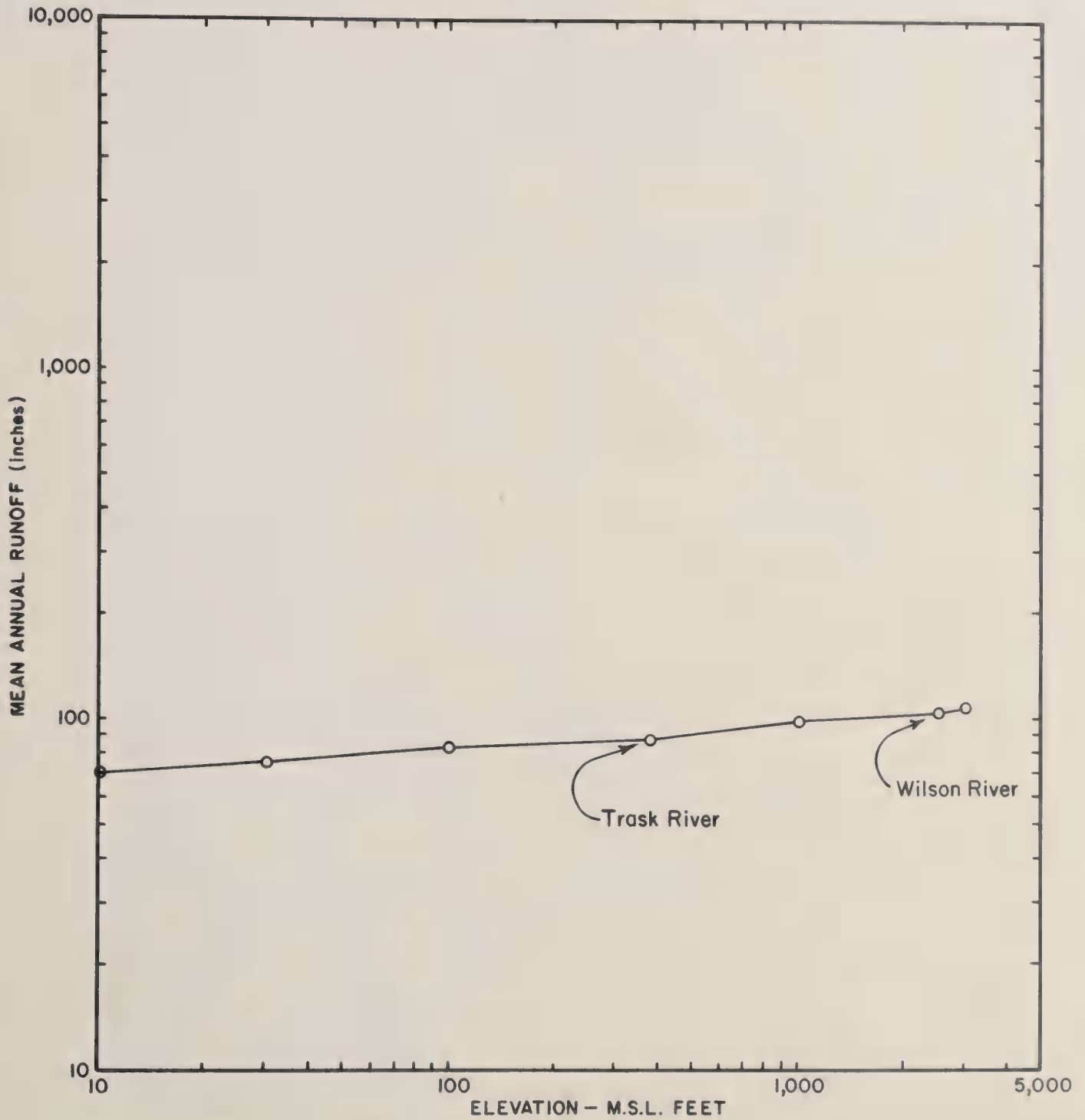


Figure IV-5

## STREAMFLOW VS. ELEVATION

DATA BASE: 1932-1974 U.S.G.S. Streamflow, Trask and Wilson Rivers



SOURCE: U.S.D.A. Study Team



T 2 N

1 N

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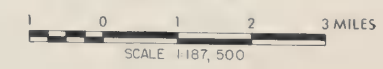
2

3



# MEAN ANNUAL RUNOFF TILLAMOOK BAY DRAINAGE BASIN TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES OREGON

JUNE 1976

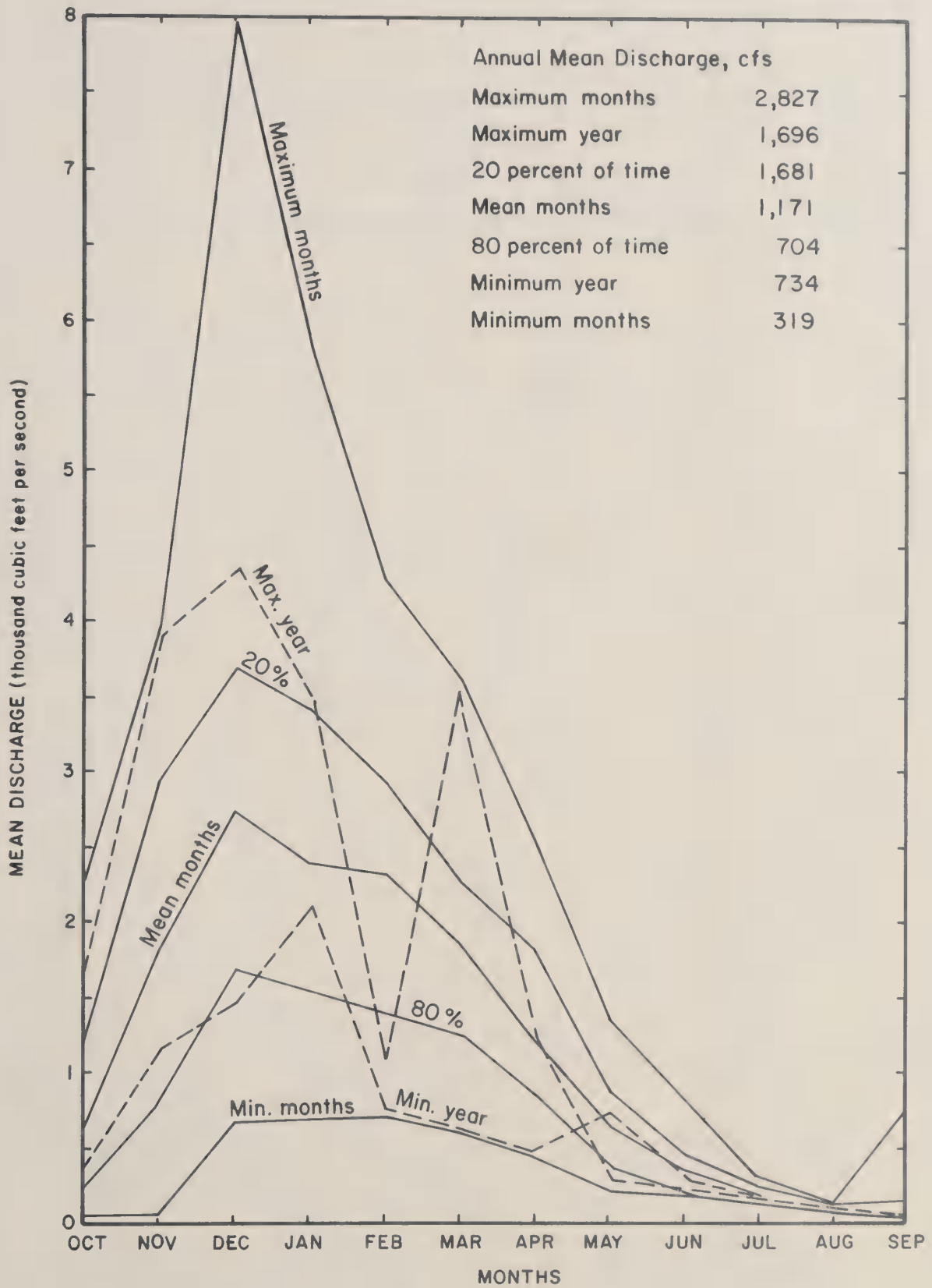


Source Data: Trask and Wilson River Stream Gage  
(USFS Runoff-Precip. Curve)



Figure IV-6

# MONTHLY DISCHARGE - WILSON RIVER NEAR TILLAMOOK, OR.



Period of record 1929-1958 — 1970 Conditions  
Drainage area: 161 sq. mi.

Figure IV-7

# FREQUENCY CURVES - WILSON RIVER NEAR TILLAMOOK, OR.

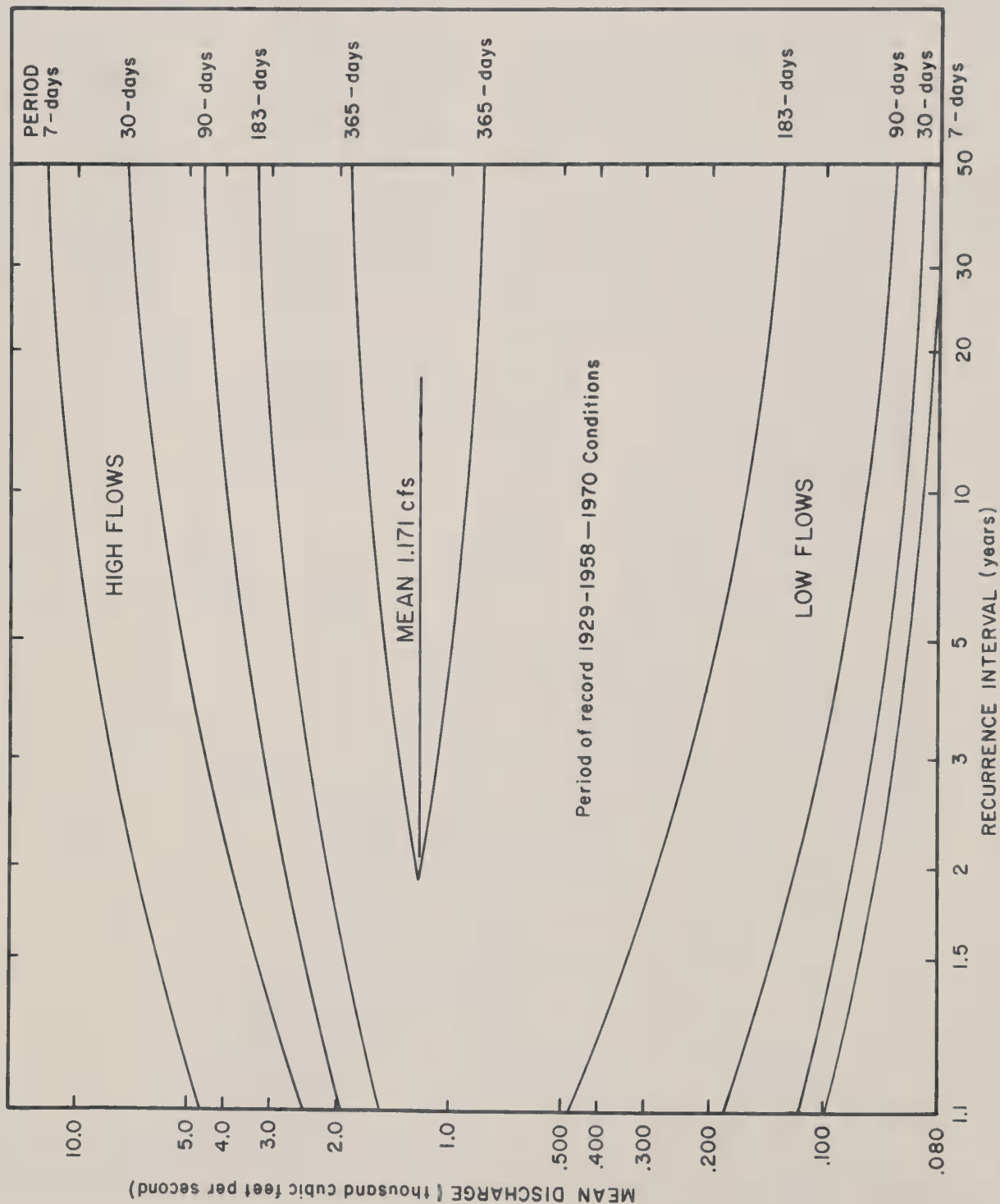


Figure IV-8

FREQUENCY CURVES OF ANNUAL PEAK FLOWS—  
WILSON RIVER NEAR TILLAMOOK, OR.

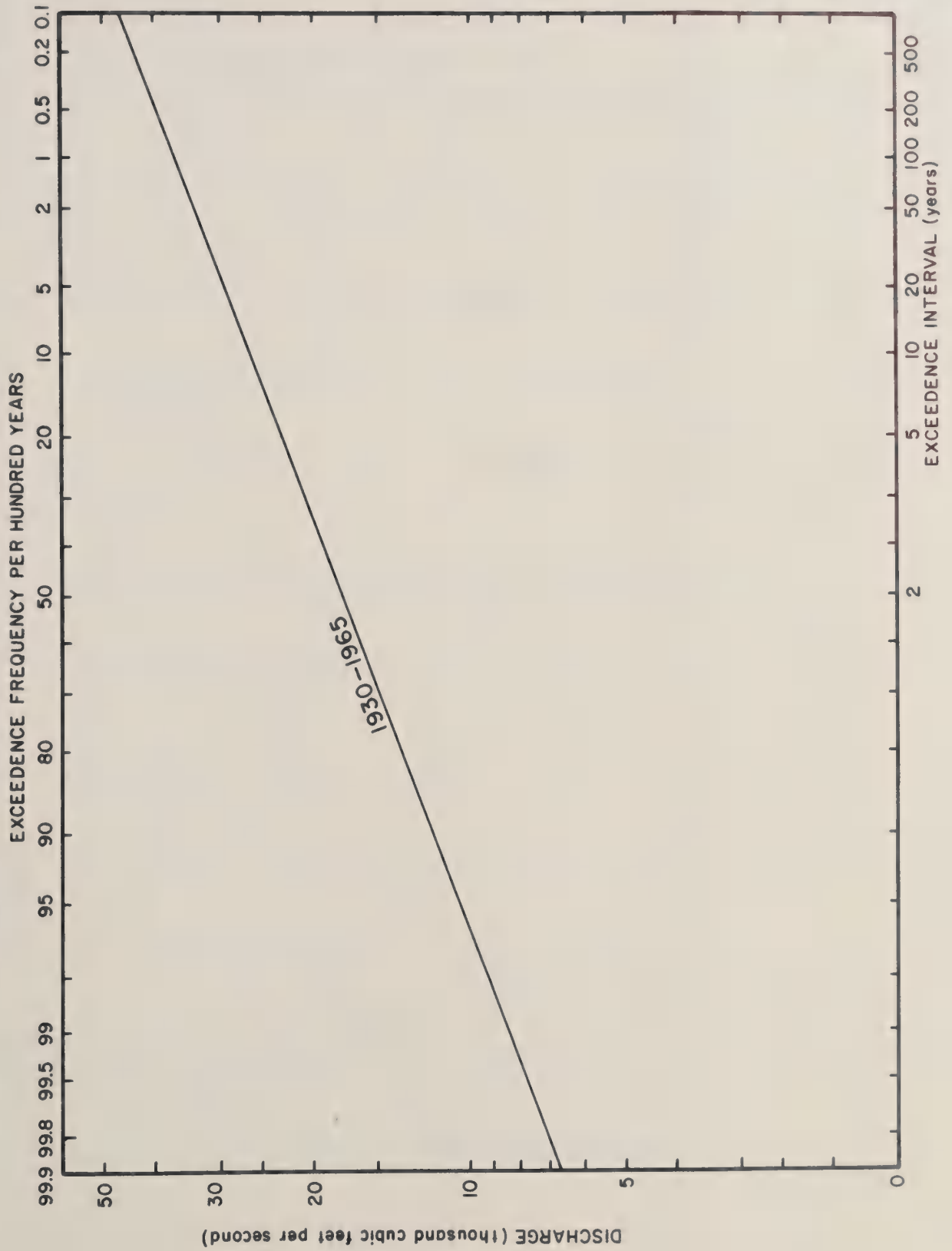
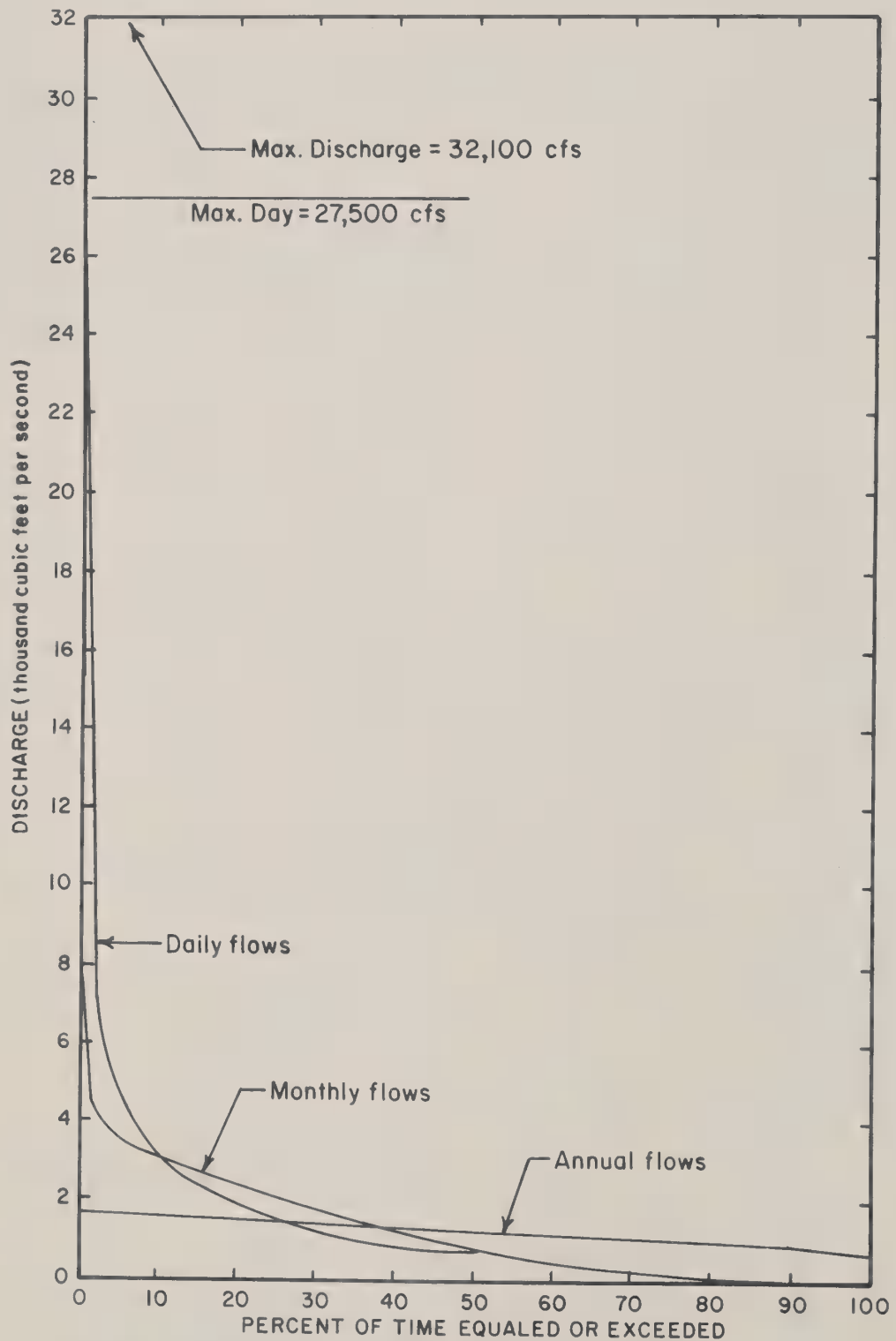


Figure IV-9

# DURATION CURVES - WILSON RIVER NEAR TILLAMOOK, OR.



Period of record 1929-1958 — 1970 Condition

Table IV-3 - OBSERVED MONTHLY MEAN DISCHARGE, IN CFS, WILSON RIVER NEAR TILLAMOOK, OREGON

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1928													
1929	342	1602	1763	1824	1026	1392	2534	401	460	101	71	80	981
1930	134	60	1847	1094	4104	1552	1025	889	355	119	81	94	946
1931	112	704	661	1695	912	2240	2050	252	330	179	98	121	779
1932	804	2250	2240	2750	2210	3320	1820	428	187	122	99	76	1360
1933	197	2970	3410	2920	2020	2890	1260	1390	876	208	118	397	1550
1934	1192	1149	7988	3722	718	1764	914	744	191	131	98	124	1579
1935	2087	3975	3091	3068	1549	2039	1131	438	196	171	106	132	1500
1936	216	794	1446	4527	2044	1668	633	932	470	266	142	120	1106
1937	88	87	2133	940	2658	2101	2550	876	637	304	169	120	1044
1938	430	3621	4000	2145	1588	2269	1445	439	183	111	78	75	1364
1939	222	1453	1744	2041	2659	1541	426	202	252	156	89	74	894
1940	271	422	3056	1527	3301	1858	926	873	181	108	79	77	1051
1941	346	1104	1430	2064	751	595	489	704	285	146	120	765	734
1942	781	1443	3119	1015	1778	943	563	617	577	278	141	95	942
1943	213	3280	3178	1647	2921	1407	1758	476	389	183	121	89	1291
1944	487	784	1666	1541	1380	1072	1165	402	359	133	86	101	763
1945	167	1149	852	2246	2535	2497	1398	896	268	127	91	432	1045
1946	206	3086	3105	3006	2736	1990	1115	352	264	298	120	97	1356
1947	615	2750	3709	1933	2233	1211	938	273	457	222	123	230	1218
1948	2230	2278	1648	2437	2596	1603	1539	1386	312	153	109	169	1368
1949	581	2216	3487	694	4268	1718	715	920	186	124	91	91	1238
1950	455	2332	2497	3055	3506	3294	1790	660	238	126	107	93	1501
1951	1285	2610	3097	3498	2944	1664	852	445	200	104	69	111	1399
1952	1942	1808	2717	1699	2453	1515	939	446	213	127	83	67	1165
1953	58	146	1718	5776	2314	1495	872	916	405	191	155	141	1182
1954	599	1950	3686	3413	3540	1215	1489	269	469	266	139	159	1420
1955	613	1922	1909	1781	1834	1930	2069	821	287	202	117	122	1128
1956	1588	3935	4368	3476	1130	3637	1238	317	268	126	104	88	1696
1957	705	1033	2398	818	2394	2170	1059	429	317	177	133	81	968
1958	198	932	3740	3036	2884	909	1943	400	201	102	68	69	1198
Mean	369	1795	2723	2380	2333	1850	1223	620	334	174	107	150	1171

Table IV-4 DEPENDABLE YIELD, WILSON RIVER NEAR TILLAMOOK, OREGON

Consecutive Years of Lowest Mean Flow	Inclusive Years	Lowest Mean Flow	Percent of 1929-58 Mean
1	1941	(cfs) 734	62.7
2	1941-42	838	71.6
3	1939-41	892	76.1
4	1939-42	905	77.4
5	1939-43	982	83.9
6	1939-44	945	80.8
7	1939-45	960	82.1
8	1939-46	1,010	86.4
9	1937-45	1,014	86.7
10	1936-45	1,023	87.8
30	1929-58	1,171	100.0

Table IV-5--TILLAMOOK BAY DRAINAGE BASIN (Forested Area)

RESPONSE	RUNOFF POTENTIAL	Acreages Classified According to Their Hydrologic Response									
		RESPONSE				Acres of Basin			Percent of Area		
		Poor	Fair	Good	Excellent	Poor	Fair	Good	Excellent		
BASIN	Sub-Basin	Poor	Fair	Good	Excellent	Poor	Fair	Good	Excellent		
Tillamook	Tillamook	2,334.93	11,596.85	25,204.35	1,094.27	40,230.40	6	29	63	3	
Kilchis	1 (Lower)	542.15	8,815.94	9,434.13		18,792.22	3	47	50		
	2 (Little South Fork)		6,397.18	523.24		6,920.42		92	8		
	3 (Upper)		18,686.76	855.00		19,541.76		96	4		
	Subtotals	542.15	33,899.88	10,812.37		45,254.40	1	75	24		
Miami	Miami	67.79	12,424.72	12,281.89		24,774.40	0	50	50		
Wilson	1 (Little North Fork)	758.16	12,030.40	6,173.67		18,962.23	4	63	33		
	2 (Main)		34,451.63	12,643.09		47,094.72		73	27		
	4 & 5 (Upper)	1,813.82	29,170.81	22,609.57	28.85	53,623.05	3	54	43	T	
	Subtotals	2,571.98	75,652.84	41,426.33	28.85	119,680.00	2	63	35	T	
Trask	1 (Lower)	987.99	33,931.45	45,517.46		80,436.90	1	42	57		
	2A (East Fork)		8,015.17	10,699.52		18,714.69		43	57		
	3 (South Fork)		10,130.81	3,178.40		13,309.21		76	24		
	Subtotals	987.99	52,077.43	59,395.38		112,460.80	1	46	53		

T= Trace Percentage Amount

## HYDROLOGIC RESPONSE

Table IV-6 is a summary of hydrologic response to runoff by forested land subbasins. This response is related to soil infiltration rates, soil depth, land slope, and is the ability of that soil mantle to store and gradually release ambient precipitation. (See "Hydrology", USDA - SCS Engineering Handbook for a more complete interpretation).

Soil Group A - Excellent Hydrologic Response to Retard Runoff - These soils have high infiltration rates even when thoroughly wetted, and consist mainly of deep, well to excessively drained, sands and/or gravels. These soils have a high rate of water transmission and result in low runoff potential.

Soil Group B - Good Hydrologic Response to Retard Runoff - These soils have moderate infiltration rates when thoroughly wetted, consisting mainly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Soil Group C - Fair Hydrologic Response to Retard Runoff - These soils have slow infiltration rates when thoroughly wetted, consisting mainly of soils with a layer that impedes the downward movement of water or soils with moderately fine to fine textures. These soils have a slow rate of water transmission. In the Tillamook area relatively shallow soils were placed in this group.

Soil Group D - Poor Hydrologic Response to Retard Runoff - These soils have very slow infiltration rates when thoroughly wetted, consisting chiefly of soils with a high permanent water table or shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission which results in flashy runoff.

Based only on these characteristics of hydrologic response, the five subbasins in the Tillamook study area are rated as follows:

1. Tillamook - Best
2. Trask
3. Miami
4. Wilson
5. Kilchis - Poorest

There has been a tremendous improvement in hydrologic response on the forested lands since burned area rehabilitation began about 1945. The Hydrologic Response Trend Table IV-6 indicates that 283 square miles of watershed have been shifted from the poor to fair category due to this massive rehabilitation effort.

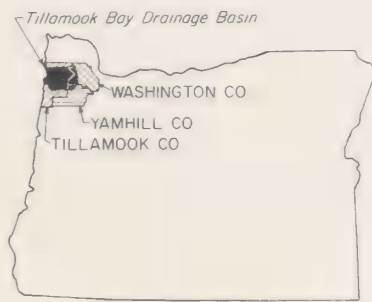
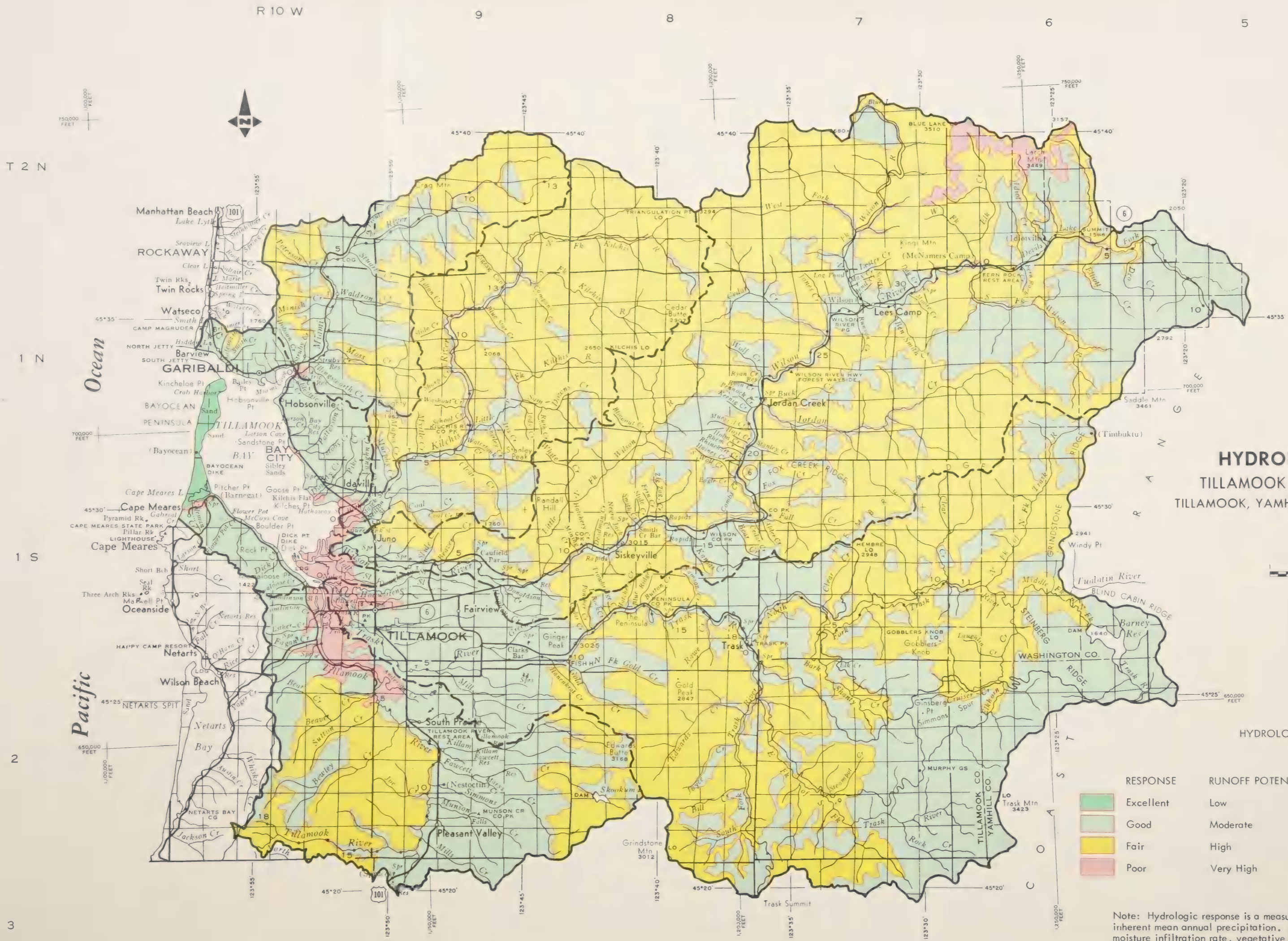
Table IV-6

## HYDROLOGIC RESPONSE TREND - FOREST LANDS

Weighted Average Hydrologic Response	1975			1945*			1900*		
	Percent Area	Square Miles	Percent Area	Percent Area	Square Miles	Percent Area	Percent Area	Square Miles	Square Miles
Excellent	<1	5.1	2	10.1	51	258.3			
Good	43	217.8	14	70.9	38	192.6			
Fair	54	273.6	26	131.8	10	50.6			
Poor	2	10.1	58	293.8	<1	5.1			
TOTAL	100	506.6	100	506.6	100	506.6			

\* Estimated from burn area map.





**HYDROLOGIC RESPONSE**  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,  
OREGON

JULY 1976  
SCALE 1:187,500  
0 1 2 3 MILES

HYDROLOGIC RESPONSE				
RESPONSE	RUNOFF POTENTIAL	ACRES	AREA PERCENT	
Excellent	Low	1,040	0.0003	
Good	Moderate	152,978	45	
Fair	High	182,272	53	
Poor	Very High	6,110	2	
		Total 342,400 Ac.	100%	

Note: Hydrologic response is a measure of the land type to orderly dispose of its inherent mean annual precipitation. Some controlling factors are land slope, soil moisture infiltration rate, vegetative cover, and aspect.



## SOIL RESOURCES

### GENERAL

Soil, the surface mantle of the earth is a basic resource. Soil characteristics are the basic building blocks for soil classification units, of which soil series are the lowest category of the system. Groups of soil series occurring together and making up a segment of the landscape in a characteristic pattern are known as soil associations.

The Soil Association Map for Tillamook Bay Drainage Basin, shows the location and relative extent of each soil association. These associations are named for the dominant soil series of which they are composed. Since the symbols used with each association appear on the map, they are not included with the following individual soil association descriptions and erosion hazards. The soils data has been developed from a recent reconnaissance-type soil survey of the eastern half of the basin by the Soil Conservation Service. A previously completed detailed soil survey of the western half was integrated into this survey on a soil association basis.

The hydrologic response is discussed in this chapter under - Climate-Hydrologic Response.

### DESCRIPTION OF SOILS

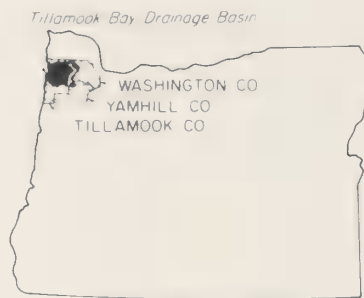
#### Active Dunelands

This land type consists of wind drifted sand without vegetation. It consists of a grayish brown, single grained, porous sand. It is used for recreation. Wind erosion hazard of this unit is very high.

#### Astoria - Ecola Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Ecola series is a moderately deep, well drained soil. The surface layer is a very dark grayish brown silty clay loam. The subsoil is a dark yellowish brown silty clay loam, underlain by siltstone bedrock. Astoria soils comprise about 50 percent of this association and Ecola soils about 35 percent. Trask and Winema soils with other less extensive soils comprise about 15 percent. Soils of this association





LOCATION MAP

## LEGEND

## DUNELANDS

AD Active Dunelands

## BOTTOMLANDS &amp; TERRACES

CA Coquille-Brallier Association, 0 to 3% slopes  
CB Chitwood-Brenner Association, 0 to 12% slopes  
NB Nehalem-Brenner Association, 0 to 3% slopes  
KW Knappa-Gaudy Association, 0 to 12% slopes  
KX Knappa-Hebo Association, 0 to 12% slopes  
KY Knappa-Nehalem Association, 0 to 12% slopes  
QG Quillayute-Ginger Association, 0 to 12% slopes

## 3 TO 30% SLOPES

AE Astoria-Ecola Association, 3 to 30% slopes  
AF Astoria-Fendall Association, 3 to 30% slopes  
AH Astoria-Hembre Association, 3 to 30% slopes  
AW Astoria-Winema Association, 3 to 30% slopes  
BK Blachly-Klickitat Association, 3 to 30% slopes  
HA Hembre-Astoria Association, 3 to 30% slopes  
HK Hembre-Klickitat Association, 3 to 30% slopes  
KG Klickitat-Hembre Association, 3 to 30% slopes

## 30 TO 60% SLOPES

AG Astoria-Fendall Association, 30 to 60% slopes  
AJ Astoria-Hembre Association, 30 to 60% slopes  
AT Astoria-Trask Association, 30 to 60% slopes  
BL Blachly-Klickitat Association, 30 to 60% slopes  
HB Hembre-Astoria Association, 30 to 60% slopes  
HL Hembre-Klickitat Association, 30 to 60% slopes  
KH Klickitat-Hembre Association, 30 to 60% slopes  
KK Klickitat-Kilchis Association, 30 to 60% slopes  
KT Klickitat-Trask Association, 30 to 60% slopes  
VY Valsetz-Yellowstone Association, 3 to 60% slopes

## 60 TO 90% SLOPES

KJ Kilchis-Klickitat Association, 60 to 90% slopes  
KJ Klickitat-Hembre Association, 60 to 90% slopes  
KL Klickitat-Kilchis Association, 60 to 90% slopes  
KU Klickitat-Trask Association, 60 to 90% slopes  
VZ Valsetz-Yellowstone Association, 60 to 90% slopes  
RK Rock outcrop-Kilchis Association, 60 to 90% slopes

Each area outlined on this map consists of one or more map units. The map units are defined by the map units. The map units are defined by the map units. The map units are defined by the map units.

# SOIL ASSOCIATION MAP TILLAMOOK BAY DRAINAGE BASIN TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON

SEPTEMBER 1978

0 1 2 3 MILES  
SCALE 1:187,500

T 2 N

1 N

1 S

2

3



are used mostly for timber production. Erosion hazard on either soil ranges from moderate to high.

Astoria - Fendall Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. Fendall series is a moderately deep, well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a yellowish brown clay underlain by siltstone. Astoria soils comprise about 75 percent of this association and Fendall soils about 20 percent. Various minor soils make up the remaining 5 percent. Soils of this association are used mostly for timber production. Erosion hazard ranges from low to moderate on both soils.

Astoria - Fendall Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltstone bedrock. The Fendall series is a moderately deep, well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a yellowish brown clay underlain siltstone bedrock. Astoria soils comprise about 55 percent of this association and Fendall soils about 30 percent. Minor soils including those of the Trask and Ecola series comprise about 15 percent. Soils of this association are used mostly for timber production. Erosion hazard on both soils is very high.

Astoria - Hembre Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltstone bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam, underlain by basalt bedrock. Astoria soils comprise about 60 percent of this association and Hembre soils about 30 percent. Klickitat and Ecola soils with other less extensive soils comprise about 10 percent. Soils of this association are used mostly for timber production. Erosion hazard of this unit is moderate.

Astoria - Hembre Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Hembre series

is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Astoria soils comprise about 40 percent of this association, Hembre soils about 25 percent, and Fendall soils about 15 percent. Trask, Winema, and other less extensive soils comprise the remaining 20 percent. These soils are used mostly for timber production. Erosion hazard for any or all of this association ranges from high to very high.

#### Astoria - Trask Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Trask series is a moderately deep, well drained soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam underlain by siltstone bedrock. Astoria soils comprise about 55 percent of this association and Trask soils about 30 percent. Winema, Ecola, and other minor soils comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard on these soils ranges from high to very high.

#### Astoria - Winema Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltstone bedrock. The Winema series is a very deep, well drained soil. The surface layer is a black silt loam. The subsoil is a dark yellowish brown silty clay or clay underlain by siltstone bedrock. Astoria soils comprise about 60 percent of this association and Winema soils about 30 percent. Minor soils including those of the Trask and Winema comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this soil association is high.

#### Blachly - Klickitat Association, 3 to 30 percent slopes

The Blachly series is a very deep, well drained soil. The surface layer is a dark reddish brown silty clay loam. The subsoil is a yellowish red silty clay. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Blachly soils comprise about 40 percent of this association and Klickitat soils about 25 percent. The remaining 35 percent is made up of soils of the Hembre, Olyic, and other less extensive series. The soils of this association are used mostly for timber production. Erosion hazard of this unit is moderate.

#### Blachly - Klickitat Association, 30 to 60 percent slopes

The Blachly series is a very deep, well drained soil. The surface layer is a dark reddish brown silty clay loam. The subsoil is a yellowish red silty clay. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Blachly soils comprise about 40 percent of this association and Klickitat soils about 30 percent. Soils of the Hembre, Olyic, Kilchis and other less extensive series comprise the remaining 30 percent. Erosion hazard of this unit is very high.

#### Coquille - Brailleur Association 0-3 percent slopes

The Coquille series is a very deep, very poorly drained soil subject to tidal overwash. The surface layer is a very dark brown mottled silt loam. The subsoil is a dark grayish brown silty clay loam. The Brailleur series is a very deep, very poorly drained peat soil subject to tidal or stream flooding. The surface is a dark brown peat. The sub-soil is a dark brown peat underlain by layers of peat and muck. The Coquille soils comprise 75 percent of this association and Brailleur soils 15 percent. Unnamed minor soils comprise the remaining 10 percent. Soils of this association are used mostly for pasture and hay production. Erosion hazard of this unit is slight.

#### Chitwood - Brenner Association, 0 to 12 percent slopes

The Chitwood series is a very deep, somewhat poorly to moderately well drained soil. The surface layer is a dark grayish brown silt loam over a mottled yellowish brown silty clay. The Brenner series is a very deep, poorly drained soil subject to flooding. The surface layer is a dark grayish brown silt loam. The subsoil is a dark grayish brown mottled silty clay. Chitwood soils comprise about 45 percent of this association and Brenner soils about 25 percent. Hebo, Nestucca, and other less extensive soils make up the remaining 30 percent. These soils are used mostly for hay and pasture. No erosion hazard is present on these soils.

#### Hembre - Astoria Association, 3 to 30 percent slopes

The Hembre series is a deep well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. Hembre soils comprise about 65 percent of this association and Astoria soils 30 percent. Minor soils, including those of the Klickitat series comprise the remaining 5 percent. Erosion

hazard of this unit is moderate.

Hembre - Astoria Association, 30 to 60 percent slopes

The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. Hembre soils comprise about 50 percent of this association and Astoria soils 35 percent. Klickitat and Fendall soils and other less extensive soils comprise the remaining 15 percent. The soils of this association are used mostly for timber production. Erosion hazard of this unit is high.

Hembre - Klickitat Association, 3 to 30 percent slopes

The Hembre series is a deep well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Hembre soils comprise about 65 percent of this association and Klickitat soils about 25 percent. Minor soils including those of the Kilchis and Marty series comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this unit is moderate.

Hembre - Klickitat Association, 30 to 60 percent slopes

The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Hembre soils comprise about 50 percent of this association and Klickitat soils about 35 percent. Minor soils including those of the Kilchis series comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard of this unit is high.

Kilchis - Klickitat Association, 60 to 90 percent slopes

The Kilchis series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Kilchis soils comprise about 50 percent of this association and Klickitat soils about 35 percent. The remaining 15 percent is rock

outcrop, Hembre soils and unnamed soils less than 12 inches deep to bedrock. These soils are used mostly for timber production. Erosion hazard of this unit is very high.

Klickitat - Hembre Association, 3 to 30 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 45 percent of this association and Hembre soils about 35 percent. Minor soils including those of the Kilchis series comprise the remaining 20 percent. The soils of this association are used mostly for timber production. Erosion hazard of this soil association ranges from low to moderate.

Klickitat - Hembre Association, 30 to 60 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 60 percent of this association and Hembre soils about 30 percent. Rock outcrop and minor soils including those of the Kilchis series comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this soil unit is high.

Klickitat - Hembre Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 70 percent of this association and Hembre soils about 25 percent. Rock outcrop and Kilchis soils comprise most of the remaining 5 percent. The soils in this association are used mostly for timber production. Erosion hazard of this soil association is very high.

Klickitat - Kilchis Association, 30 to 60 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Kilchis

series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. Klickitat soils comprise about 40 percent of this association and Kilchis soils about 30 percent. Hembre soils, rock outcrop and unnamed soils less than 12 inches deep to bedrock comprise the remaining 30 percent. These soils are used mostly for timber production. Erosion hazard of this soil association is high.

#### Klickitat - Kilchis Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Kilchis series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. Klickitat soils comprise about 40 percent of this association and Kilchis soils about 25 percent. Hembre soils, rock outcrop and unnamed soils less than 12 inches deep to bedrock comprise the remaining 35 percent. The soils in this association are used mostly for timber production. Erosion hazard of this unit is very high.

#### Klickitat - Trask Association, 30 to 50 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Trask series is a moderately deep, well drained soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam. Klickitat soils comprise about 55 percent of this association and Trask soils about 30 percent. Minor soils including those of the Kilchis, Astoria and Hembre series comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard of this soil association ranges from moderate to high.

#### Klickitat - Trask Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Trask series is a moderately deep, well drained soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam. Klickitat soils comprise about 60 percent of this association and Trask soils about 30 percent. Minor soils including those of the Hembre and Astoria series comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this unit is moderate to high.

#### Knappa - Gauldy Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Gauldy series is a deep, excessively drained soil subject to flooding. The surface layer is a dark brown loam. The subsoil is a dark yellowish brown loam. The substratum is a very gravelly sand. Knappa soils comprise about 55 percent of this association and Gauldy soils about 25 percent. Less extensive soils including those of the Meda, Gardiner and Nestucca series comprise the remaining 20 percent. These soils are used mostly for hay, pasture and timber production. Erosion hazard of this unit is slight to moderate.

#### Knappa - Hebo Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Hebo series is a very deep, poorly drained soil. The surface layer is a very dark gray silty clay loam. The subsoil is a mottled dark gray clay. Knappa soils comprise about 50 percent of this association and Hebo soils about 30 percent. The remaining 20 percent is Chitwood, Quillayute and other less extensive soils. The soils in this association are used mostly for hay and pasture. The erosion hazard of this soil association ranges from slight to moderate.

#### Knappa - Nehalem Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Nehalem series is a very deep, well to moderately well drained soil subject to flooding. The surface layer is a very dark brown silt loam. The subsoil is a dark brown silty clay loam. Knappa soils comprise about 40 percent of this association and Nehalem soils about 30 percent. Gauldy and Nestucca soils and other less extensive soils comprise the remaining 30 percent. These soils are used mostly for hay and pasture. Erosion hazard of this unit ranges from slight to moderate.

#### Nehalem - Brenner Association, 0 to 3 percent slopes

The Nehalem series is a very deep well to moderately well drained soil subject to flooding. The surface layer is a very dark brown silt loam. The subsoil is a dark brown silty clay loam. The Brenner series is a very deep, poorly drained soil subject to flooding. The surface layer is a very dark grayish brown silt loam. The subsoil is a dark grayish brown mottled silty clay. Nehalem soils comprise about 65 percent of this association and Brenner soils about 20 percent. Less

extensive soils including those of the Nestucca, Gauldy and Gardiner series comprise the remaining 15 percent. These soils are used mostly for hay and pasture. Erosion hazard of this unit is very slight.

#### Quillayute - Ginger Association, 0 to 12 percent slopes

The Quillayute series is a very deep, well drained soil. The surface layer is a black silt loam. The subsoil is a yellowish brown silty clay loam. The Ginger series is a deep, somewhat poorly drained soil. The surface layer is a black silt loam. The subsoil is a mottled grayish brown silty clay. Quillayute soils comprise about 60 percent of this association and Ginger soils about 20 percent. Less extensive soils including those of the Hebo and Chitwood series comprise the remaining 20 percent. The soils of this association are used mostly for hay and pasture. Erosion hazard of this soil association ranges from very slight to moderate.

#### Rock outcrop Kilchis Association, 60 to 90 percent slopes

This land type consists of barren rocky slopes, ridges and rock escarpments. The Kilchis series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. Rock outcrops comprise about 65 percent of this association and Kilchis soils about 25 percent. Unnamed soils less than 12 inches deep to bedrock comprise the remaining 10 percent. The soils in this association are watershed and wildlife areas with some used for timber production. Erosion on rock outcrops would be very slight but may vary depending on the type of rock. Erosion hazard of this soil association is high.

#### Valsetz - Yellowstone Association, 3 to 60 percent slopes

The Valsetz series is a moderately deep, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam underlain by intrusive igneous rock. The Yellowstone series is a shallow, somewhat excessively drained soil. The surface layer is a dark brown gravelly loam. The subsoil is a very stony loam over igneous rock. Valsetz soils comprise about 55 percent of this association and Yellowstone soils about 30 percent. Less extensive soils including those of the Mulkey series comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard of this soil association ranges from slight to high.

#### Valsetz - Yellowstone Association, 60 to 90 percent slopes

The Valsetz series is a moderately deep, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam underlain by intrusive igneous rock. The Yellowstone series is a shallow somewhat excessively drained soil. The surface layer is a dark brown gravelly loam. The subsoil is a very stony

loam over igneous rock. Valsetz soils comprise about 45 percent of this association and Yellowstone soils about 35 percent. Rock outcrop and less extensive soils including those of the Mulkey series comprise the remaining 20 percent. The soils in this association are used mostly for timber production. Erosion hazard of this unit is very high.

#### POTENTIAL SURFACE EROSION HAZARD

This interpretation compares the relative rapidity and amount of erosion by water after removal of protective vegetation and organic layer. The ratings were made after considering the effects of soil structure, texture, depth, permeability, slope, bedrock type and degree of fracturing, rate of geologic erosion, and visual observations. Since these ratings are based on the soil's inherent capacity to erode, climatic factors such as storm intensity or frozen soil conditions are not considered.

Slight indicates surface soil loss and problems of erosion control are generally minimal, assuming that moving water is not permitted to concentrate on exposed mineral soil. Soils placed in this rating usually have most of the following characteristics: Gentle slopes, strong structure, good permeability, and deep sola. Minimum practices may include careful construction of water bars on disturbed areas where running water may accumulate, such as tractor roads, trails, and fire lines. Potential soil loss is less than 5 tons per acre per year.

Moderate indicates that normal forest land management practices should be accompanied by careful erosion control measures that are necessary to hold erosion at a minimum and maintain soil productivity. Soils with this rating will generally have most of the following characteristics: Moderate to long slopes, weak to moderate structure, moderately thin sola, and moderate permeability. The soil damage may be sheet and gully erosion or a reduction in fertility caused by the removal of soil fines. Minimum land management practices should include intensive water barring of skid roads, trails, fire lines, and other disturbed areas. Yarding practices which cause a minimum disturbance, such as uphill cable or skyline, are desirable. Potential soil loss varies from 5 to 10 tons per acre per year.

Severe indicates that surface erosion will be high when the organic cover is removed by land management practices. Soils with this rating will have most of the following characteristics: Long, steep slopes, massive to weak structure, shallow sola, and poor permeability. They may be situated in topographic positions subject to rapid geologic erosion. Many soils with this rating are at or near the angle of repose. Soil damage from erosion may be sheet erosion, gullying, and the loss of soil fines. Some areas have completely lost soil materials down to bedrock. Great caution should be exercised when

logging in these areas. It is vital to maintain the soil organic cover as nearly to its original condition as possible. For this reason burning should be done with the utmost care and timed when the soil and litter are moist. From the soil erosion viewpoint there will be situations where burning is not recommended.

Road grades should be kept low with frequent water diversion structures. All fire lines and skid roads should be intensively water barred, with the water bars placed so that they drain onto vegetated ground, thus preventing further erosion. Where roads parallel stream channels, adequate distance should be maintained to prevent stream pollution. Waste materials should be dumped in areas where they will not reach streams and should be protected from surface erosion by covering with litter and/or establishing grass cover. Tractor logging is not recommended on these areas. The skyline method does much less soil damage. If jammer logging is done, great care should be exercised to hold soil disturbance at a minimum. Logs should be yarded uphill whenever possible.

In general, when planning a logging operation on these soils, each area should be critically analyzed. Some areas will be more critical than others due to topographical considerations and proximity of major streams. In some areas it may be permissible to skyline log only, while in other areas it may be desirable to completely refrain from logging. Potential soil loss varies from 10-30 tons per acre per year.

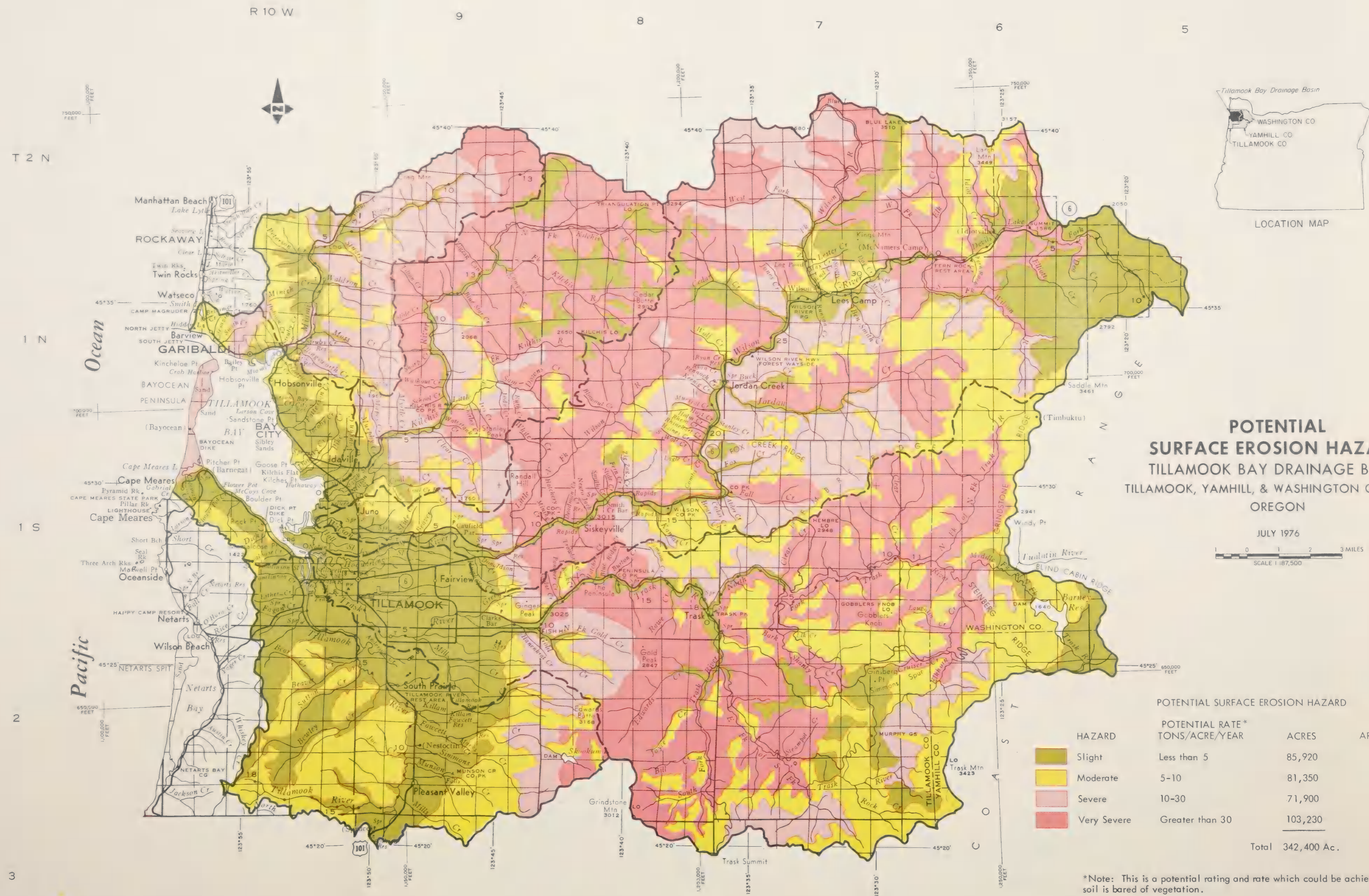
Very severe indicates that surface soil loss will be far greater than normal when the land cover is removed by natural or management practice means. Soils with this rating are typically on long, very steep, deeply dissected slopes at the higher elevations. These areas generally have shallow soils and can least afford erosion. Many of these areas were severely disturbed by wildfire and have greatly reduced capability to produce commercial timber, particularly when located at higher precipitation-runoff zones. The surface erosion potential in these areas is greater than 30 tons per acre per year.

Data from Table IV-7 indicates that when all the forested lands in the basin are considered, the potential erosion hazard areas are distributed as follows:

POTENTIAL SURFACE EROSION Tons/Acre/Year	BASIN Percent	AREA Square Miles
Slight (0-5)	22.3	115.5
Moderate (5-10)	24.8	125.6
Severe (10-30)	18.7	94.8
Very Severe (30+)	33.7	170.7
TOTAL	100.0	506.6

Table IV-7--SUBBASIN ACREAGES CLASSIFIED ACCORDING TO THEIR POTENTIAL SURFACE EROSION HAZARD

BASIN	Sub-Basin	HAZARD					Total Acres of Basin	Percent of Area			
		Slight	Moderate	High	Very High			Slight	Moderate	High	Very High
Tillamook	Tillamook	19,576.99	15,972.70	3,700.51	980.20		40,230.40	49	40	9	2
Kilchis	1 (Lower)	5,160.51	3,572.06	5,195.28	4,715.81		18,643.66	28	19	28	25
	2 (Little South Fork)	342.59	1,089.62	1,318.40	4,341.12		7,091.73	5	15	19	61
	3 (Upper)	3,844.93	591.98	43.44	15,038.66		19,519.01	20	3	0	77
	Subtotals	9,348.03	5,253.66	6,557.12	24,095.59		45,254.40	21	12	14	53
Miami	Miami	2,787.71	5,139.28	13,106.55	3,740.86		24,774.40	11	21	53	15
Wilson	1 (Little North Fork)	3,244.35	3,469.84	2,374.18	9,474.66		18,563.03	17	19	13	51
	2 (Main)	4,830.24	8,940.19	15,122.05	17,183.68		46,076.16	10	19	33	38
	4 & 5 (Upper)	16,823.04	9,562.63	11,660.93	16,994.21		55,040.81	31	17	21	31
	Subtotals	24,897.63	21,972.66	29,157.16	43,652.55		119,680.00	21	18	24	37
Trask	1 (Lower)	18,982.18	26,034.08	8,556.16	26,533.92		80,106.34	24	32	11	33
	2A (East Fork)	2,331.75	7,828.32	2,951.26	5,915.39		19,026.72	12	41	16	31
	3 (South Fork)	279.20	2,912.22	166.56	9,969.76		13,327.74	2	22	1	75
	Subtotals	21,593.13	36,774.62	11,673.98	42,419.07		112,460.80	19	33	10	38



**POTENTIAL  
SURFACE EROSION HAZARD  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,  
OREGON**

JULY 1976  
SCALE 1:187,500  
0 1 2 3 MILES

POTENTIAL SURFACE EROSION HAZARD			
HAZARD	POTENTIAL RATE* TONS/ACRE/YEAR	ACRES	AREA PERCENT
Slight	Less than 5	85,920	25
Moderate	5-10	81,350	24
Severe	10-30	71,900	21
Very Severe	Greater than 30	103,230	30
		<b>Total</b>	<b>342,400 Ac. 100%</b>

\*Note: This is a potential rating and rate which could be achieved when the soil is bared of vegetation.



## VEGETATIVE RESOURCES

### GENERAL COVER AND LAND USE

Vegetative resource data was derived from satellite imagery using the LANDSAT Program (PIXSYS) at the Earth Resources Remote Sensing Laboratory (ERSAL) at Oregon State University. Digital tapes of the satellite data for July 25, 1975 were used in the program.

The primary purpose of the Tillamook Bay Study is directed towards erosion and sediment programs. Vegetative resources were inventoried in categories which relate to these problems and are summarized in Table IV-8. The following discussion is in terms of these categories, which are designated by symbols on the Vegetative Cover and Land Use Maps for the five subbasins included in this study.

Most of the Tillamook Bay Drainage (363,520 acres) is classed as forest lands. Exceptions are the coastal valley, beaches, small meadows along the narrow stream bottoms, and the bay itself. There are 323,050 acres or 89 percent of the basin within the forest resource area. The agriculture, non-forest, urban and miscellaneous resource area includes 29,490 acres (8 percent) and the Bay area and the rivers include 10,980 acres (3 percent). Both are defined in Table IV-8, Generalized Land Cover.

Land uses in Tillamook Bay Drainage Basin would be considered by most planners to be very intensive. The intensity with which the resources are used could be related to the changes in elevation or in relationship to the proximity to the Estuary. The estuarine area receives heavy demands from nearly all of the economic community, including fisheries, lumbering, dairying, and recreation services,

There is little opportunity left for additional development on the Tillamook Bay shoreline because of the current demands and the land ownership pattern. Bayocean Peninsula is in county and federal ownership, tidal mudflats are in state and county ownership, and the surrounding uplands are in large timber industry ownerships. The floodplain is owned mostly by the many dairymen in the area.

Table IV-8, GENERALIZED LAND COVER  
TILLAMOOK BAY DRAINAGE BASIN, OREGON

Subbasin	Unit	Forest	Nonforest	Water <sup>1/</sup>	Total
Tillamook	Acres	35,120	7,740	280	43,140
Trask	Acres	101,350	11,080	600	113,030
Wilson	Acres	118,850	6,090	600	125,540
Kilchis	Acres	43,240	3,400	280	46,920
Miami	Acres	24,490	990	70	25,550
Bay Area	Acres		190	9,150	9,340
Total	Acres	323,050	29,490	10,980	363,520
Percent		89	8	3	100

<sup>1/</sup> Includes only streams 10 feet or more in width and water bodies of 4 acres or more.

#### LAND USE PLANNING

Tillamook County and its municipalities have been active in land use planning since 1945 when the third of the big fires led to the planning for reforestation and protection of the Tillamook Burn. Various county, state and federal regulations have intensified these planning efforts, especially in the 1970's.

The Tillamook County Planning Commission prepared a report on land use in the Tillamook Bay Area in 1967. The State Land Board inventoried fill areas of the Estuary in 1972. The Tillamook Bay Task Force did an overview of Tillamook Basin, taking a general look at its resources, uses, and problems in 1973 and that led to this USDA Study. An Advisory Committee to the Governor made a statewide study of current and future environmental quality problems in Oregon in 1971. The Oregon Legislative Assembly acted in 1971 to pass several acts with far reaching environmental quality implications.

Oregon's coastal goals and guidelines effective January 1, 1977 have been adopted for planning resource uses of estuaries, coastal shorelines, beaches, dunes, and the ocean 200 mile zone. The report,

Land and Water Use Guidelines for the Development of Tillamook Bay Estuary identifies 15 shoreline planning units. To facilitate comprehensive planning in compliance with the Estuarine Resources Goal, the Oregon Land Conservation and Development Commission (LCDC) has released estuarine classification guidelines indicating that Tillamook Bay should be classed as a shallow-draft barge estuary. That designation provides for commercial and recreational development requiring an access channel not greater than 22 feet deep upstream of the jetties.

Tillamook County has adopted a comprehensive land use plan as well as zoning and subdivision ordinances. These serve as the basic controls on development outside incorporated areas. In addition, the county has prepared a comprehensive water and sewerage study, transportation plan, and parks and recreation study.

On the local level, the communities of Tillamook and Bay City both have planning commissions, comprehensive plans, and zoning ordinances. Bay City has prepared a subdivision ordinance. Garibaldi, after having prepared a comprehensive plan in 1964, has formed a citizens advisory committee to prepare a new plan assisted by the Clatsop Tillamook Intergovernmental Council.

The ports of Bay City and Tillamook Bay had a development program and plan prepared for the bay. The plan's recommended program and proposed development areas were not widely accepted by the community. Both port districts also have single element development plans that have not been widely circulated.

Following a series of public meetings and revisions, Statewide Planning Goals and Guidelines for Coastal Resources were adopted by the Land Conservation and Development Commission and took effect on January 1, 1977. The adopted goals include No. 16 (Estuarine Resources), No. 17 (Coastal Shorelands Goal), No. 18 (Beaches and Dunes Goal), and No. 19 (Ocean Resources Goal). The proposed navigation improvements at Tillamook would comply with the Estuarine Resources Goal, since construction would be subtidal areas seaward of the estuary. The absence of sand-bypass provisions as a part of project construction could make the proposal inconsistent with the Beaches and Dunes Guidelines. Maintenance of the navigability of Tillamook entrance would be consistent with other statewide planning goals related to transportation. The U.S. Geological Survey, Estuarine Research Section, is conducting a five-year study of the Tillamook Estuary.

Urban use in the basin is somewhat limited by surrounding land ownership. The area's most intensive urban concentration occurs in the City of Tillamook. Other urban areas include Garibaldi and Bay City.

Outside the urban areas, the valley floor is largely occupied by the dairies which maintain pastures or hay forage production. The uplands are mostly covered by forests. The land ownership largely follows this management scheme as does land use planning in the basin.

The plans for present and future uses of the resources appear to be well formulated. These uses may not always be in the best interest of the environment. Some changes may surface as the result of the ongoing planning efforts. Also, a change in the approach and timing of the uses may be advisable if goals in sediment reduction are to be reached. This will be elaborated upon under managerial strategies in Chapter X.

### CROPLAND RESOURCES

Almost all of the cropland is devoted to production of forage crops. The forage is used as feed for dairy cattle.

The cool, moist climate helps to produce good yields from the various mixtures of grasses and legumes. However, it is difficult to produce good quality hay so the forages are harvested by pasturing, green chopping, or made into silage. Most of the hay used in this area is alfalfa hay trucked in from eastern Oregon.

There are 23,540 acres of croplands within the basin. These lands are used for production of hay, silage, and pasture. There are an additional 3,430 acres of forest lands that are also grazed. The above acreage figures are gross acreages and include the roads serving these areas. Acreage figures in Table IV-9 are net acreages.

There are 4,680 acres of irrigated and sub-irrigated croplands that are used for production of silage, green-chop, and pasture.

There are 13,470 acres of improved dryland pasture. These fields are sometimes harvested as green chop or silage in the early summer when plant growth is vigorous and livestock grazing cannot keep up with the plant development.

There are 4,020 acres of unimproved dryland pasture. Vegetation is predominantly grasses and legumes native to the area. These fields are generally too rough for harvesting by machinery and are usually grazed.

There are 1,370 acres of poorly drained brush-pasturelands that are in low lying tidal effected areas. The vegetation contains sedges, rushes and saltwater-tolerant grasses. They are used for livestock grazing.

### FOREST RESOURCES

There are 323,050 acres of forest lands in the basin. This acreage includes 319,620 acres within the forest resource area and 3,430 acres in the agricultural resource area. Forest land managers have classified 318,520 acres of forest lands as commercial forest and 4,530 acres as noncommercial forest.

Table IV-9--LAND COVER VS. LAND-USE, TILLAMOOK BAY DRAINAGE BASIN, OREGON 1975

Land Cover Designation <sup>1/</sup>	Total Acres	Pasture	Recreation	Timber	Land Uses		Gravel Operations	Urban	Permanent R/W	Water-shed
					Cropland					
Sand & Rock	4,220		230						460	3,530
Water	10,980		10,980							
Tall Brush Dominating	34,870	1,330		30,460					3,080	(2,100) <sup>2/</sup>
Grass	22,170	20,460			710		20		980	
Low Brush, Logging, Slash, Seedlings, Clearcuts & Burns	53,910			48,990					4,920	
Bare Soil (Clearcuts & Burns)	6,410			4,350				1,730	330	
Forested (Sapling size & larger)										
a. Conifers	179,700		3,000	161,340					15,360	(19,530) <sup>2/</sup>
b. Hardwoods	51,260		850	46,140					4,270	(20) <sup>2/</sup>
Total	363,520	21,790	15,060	291,280	710		20	1,730	29,400	3,530

<sup>1/</sup> This is the cover condition of the soil on the 23rd of July 1975

<sup>2/</sup> The primary land use is timber production. The lands also serve as watersheds for municipal storage reservoirs.

Noncommercial forest lands in the basin include areas of 70 percent slopes and steeper with very shallow, erosive soils. Rock outcrops often are associated with noncommercial forest areas.

A total of 3,850 acres of the commercial forest land is reserved from normal timber harvest practices. This acreage includes 15 recreation sites and areas on which recreation values take priority over timber harvest.

There are also 188 miles of stream and highway corridors. Timber harvest practices on the state-owned portion of these corridors have been modified to recognize open space values.

The commercially available portion of the forest lands is primarily managed for timber production. Other uses are allowed, but only to the extent that these uses do not interfere with timber growing and harvesting programs.

Natural forest eco-zones found in the Tillamook Drainage Basin include the Sitka spruce eco-zone and the western hemlock eco-zone. The Sitka spruce zone is generally limited to areas under 800 feet in elevation. The balance of the basin lies in the western hemlock zone. Fire has historically been a part of the ecologic development of the basin forest resources. The climax forest communities of the two eco-zones were limited to a fraction of their normal environment by periodic fires (fires of 100 to 300-year intervals in Tillamook Basin) which prevented development of climax communities.

Douglas fir tends to dominate these eco-zones when periodic fires occur. This was the situation at the turn of the century. Massive Douglas fir dominated the forests of the area later known as "Tillamook Burn". Periodic fires occurred over the basin for 33 years, beginning with the 1918 fire. Each succeeding fire ran unchecked even with all out efforts by man. The extent of each fire was determined more by changes in weather than by human effort. The fires were not limited to the Tillamook Bay Drainage, crossing the crest of the Coast Range and burning a portion of the Willamette River Basin. The Salmonberry Fork of the Nehalem River was also burned. The 1951 fire was the last of the big fires. The five fires, along with timber harvest, have removed most of the oldgrowth stands so that in 1975 only 30,650 acres remained in the basin.

Much of the forest resource area was so badly damaged by repeated burning that the soils lay bare with little chance of natural regeneration. Erosion problems were extensive and downstream sedimentation of the estuarine system increased drastically. A reforestation effort that was to become one of the largest undertaken in this country was launched by the State Board of Forestry in 1949. Culmination of this program came in 1973 with the successful reforestation of 217,800 acres, including portions of the Willamette and Nehalem Drainages.

The new forests will not necessarily fit the description of tree species normally found in these eco-zones. The micro-climate of the soils has been temporarily changed. Spruce plantations have been successfully established well above 800 foot elevations and ponderosa pine, normally an eastside species, now grows in Tillamook. Mixed stands of hemlock, spruce and Douglas fir in different combinations have been introduced to take advantage of potential productivity capabilities of the different soils, slopes and aspects.

The forest resources were inventoried in categories which relate to erosion rather than productivity. This inventory is summarized on Table IV-10 and the categories are defined as follows:

#### Clearcuts

Areas included in this category are those which were clearcut within the last 10-15 years and the vegetated portion of the soil is dominated by brush and slash. The conifers, if present, are not large enough to fill in and dominate the area. There were 13,610 acres of these stands in 1975.

#### Burns

Areas included in this category are those which are within the boundary of the Tillamook fires and have not been successfully reforested, or the trees are not large enough to fill in and dominate the area. Brush species now dominate the vegetated portion of the soils. Many of the sites in this category have a satisfactory number of coniferous trees which will eventually attain dominance over the brush. There were 44,980 acres in this category in 1975.

#### Old Growth

These are timber stands which are relatively undisturbed. The old-growth (120 plus years old) conifers dominate the tree canopy. There were 30,560 acres of these stands in 1975.

#### Mature Second Growth

These are timber stands which have been established following early timber harvest. These stands are generally 50-90 years old and are well stocked with near crown closure. There were 34,250 acres of these stands in 1975.

#### Pole-sized Stands

These are satisfactorily stocked conifer timber stands which have attained pole-size, generally 20-40 years old. About 44,200 acres of these stands are the result of the reforestation effort of the State Forester on the Tillamook Burn. There was a total of 72,830 acres of these stands in 1975.

Table IV-10--FOREST RESOURCE INVENTORY, TILLAMOOK BAY DRAINAGE BASIN, OREGON 1975

Resource Area/Vegetative Condition	Unit	Total	Tillamook	Trask	Wilson	Kilchis	Miami
Forest Resource Area							
1. Clearcuts							
a. > 75% bare soil	Acres	1,570	950	40	40	180	360
b. 50-75% bare soil	Acres	2,150	940	140	180	210	680
c. 25-50% bare soil	Acres	5,820	2,350	370	400	660	2,040
d. < 25% bare soil	Acres	4,070	1,880	110	310	480	1,290
		(13,610)	(6,120)	(660)	(930)	(1,530)	(4,370)
2. Burns							
a. > 75% bare soil	Acres	740	-	190	490	40	20
b. 50-75% bare soil	Acres	220	-	130	60	20	10
c. 25-50% bare soil	Acres	24,680	-	11,060	9,500	3,960	160
d. < 25% bare soil	Acres	19,340	-	9,120	6,320	3,390	510
		(44,980)	( )	(20,500)	(16,370)	(7,410)	(700)
3. Old-growth stands	Acres	30,560	1,290	10,140	15,010	2,630	1,490
4. Mature second growth stands	Acres	34,250	4,530	8,180	13,580	4,830	3,130
5. Pole-sized stands	Acres	72,830	11,920	18,060	27,960	9,390	5,500
6. Sapling-sized stands	Acres	39,030	3,930	16,090	12,960	3,820	2,230
7. Tall brush and seedlings	Acres	33,500	3,010	12,540	11,590	4,030	2,330
8. Hardwood stands	Acres	50,860	2,680	14,470	20,050	9,140	4,520
Subtotal		319,620	33,480	100,640	118,450	42,780	24,270
Agricultural Resource Area							
1. Mature second-growth stands	Acres	180	80	30	10	50	10
2. Pole-sized stands	Acres	430	130	140	110	30	20
3. Sapling-sized stands	Acres	2,420	1,280	460	250	260	170
4. Hardwood stands	Acres	400	150	80	30	120	20
Subtotal	Acres	3,430	1,640	710	400	460	220
Total	Acres	323,050	35,120	101,350	118,850	43,240	24,490

### Sapling-sized Stands

These are satisfactorily stocked stands which have attained size and crown density sufficient to dominate the sites. These stands may be as young as 5 years. However, it usually takes 10 years to attain crown dominance over brush and hardwoods. Trees are generally two to four inches in diameter by then. There were 39,030 acres of these stands in 1975. There were 27,980 acres of these stands as a result of the State Forester's reforestation efforts.

### Tall Brush and Seedlings

Tall brush with both hardwood and conifer seedlings occupy the stand. Without specie conversion, hardwoods will dominate the stand. There were 33,500 acres in this category in 1975.

### Hardwood Stands

These stands, consisting mostly of red alder, are generally 15-40 years of age. The stands are well stocked with near crown closure. There was a total of 50,860 acres of these stands in 1975.

## PRODUCTIVITY

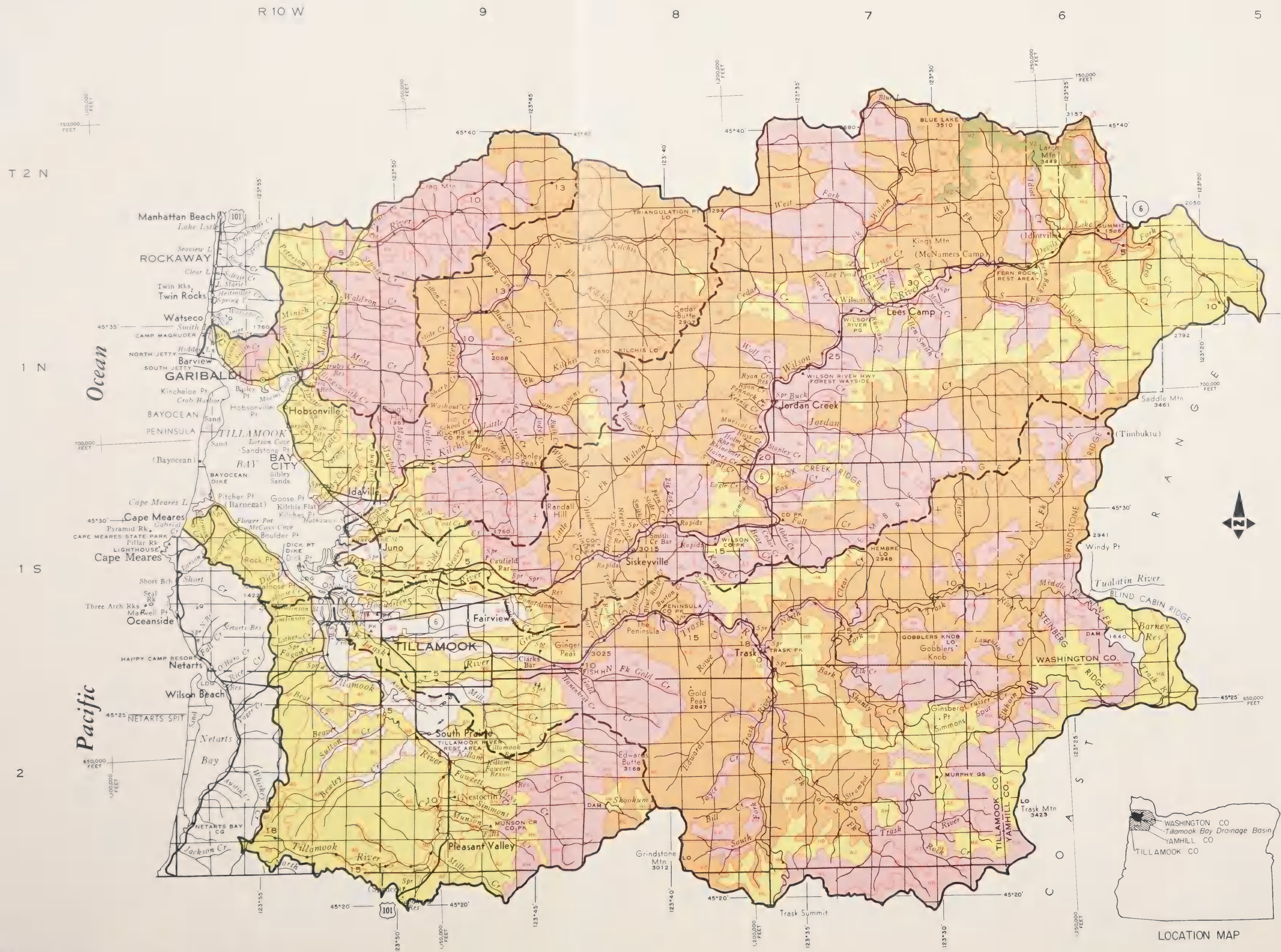
Productivity of forest soils is often expressed in terms of site class.<sup>1/</sup> Site Class (I) is the most productive and Site Class (V) the least productive. The average volume of a fully stocked 90-year-old stand on Site I soils in the Basin would be about 18,000 cubic feet per acre. The same stand on Sites II, III, IV, and V would be about 15,000 cubic feet, 12,400 cubic feet, 8,500 cubic feet, and 5,500 cubic feet per acre, respectively.

Erosion problems affecting productivity on Sites I, II, and III have a very significant effect on the timber economy of the Basin. Nearly 95 percent of the forest soils fall within these three site classes, as shown on the Timber Site Class Map (Figure IV-10). Most of the erosion also occurs on these soils. It follows that erosion problems on forest lands in the Tillamook area will be of great concern both environmentally and economically.

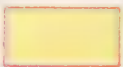
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<sup>1/</sup> The soil series associated with the Astoria series are classified as site class II for productivity. However, Astoria soils are generally rated as site class I.





LEGEND



TIMBER SITE CLASS II

- AE Astoria-Ecola Association, 3 to 30% slopes
- AF Astoria-Fendall Association, 3 to 30% slopes
- AG Astoria-Fendall Association, 30 to 60% slopes
- AH Astoria-Hembre Association, 3 to 30% slopes
- AJ Astoria-Hembre Association, 30 to 60% slopes
- AW Astoria-Winema Association, 3 to 30% slopes
- HA Hembre-Astoria Association, 3 to 30% slopes
- HB Hembre-Astoria Association, 30 to 60% slopes
- HK Hembre-Klickitat Association, 3 to 30% slopes
- HL Hembre-Klickitat Association, 30 to 60% slopes
- KX Knappa-Hebo Association, 0 to 12% slopes
- KY Knappa-Nehalem Association, 0 to 12% slopes
- NB Nehalem-Brenner Association, 0 to 3% slopes



TIMBER SITE CLASS III

- AT Astoria-Trask Association, 30 to 60% slopes
- BK Blachly-Klickitat Association, 3 to 30% slopes
- BL Blachly-Klickitat Association, 30 to 60% slopes
- KG Klickitat-Hembre Association, 3 to 30% slopes
- KH Klickitat-Hembre Association, 30 to 60% slopes
- KJ Klickitat-Hembre Association, 60 to 90% slopes
- KK Klickitat-Kilchis Association, 30 to 60% slopes
- KL Klickitat-Kilchis Association, 60 to 90% slopes
- KT Klickitat-Trask Association, 30 to 60% slopes
- KW Knappa-Gauldy Association, 0 to 12% slopes



TIMBER SITE CLASS IV

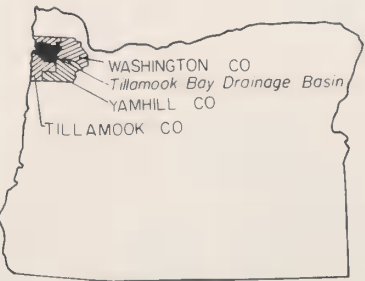
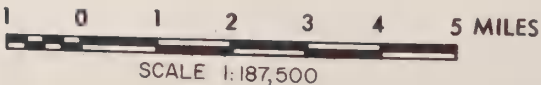
- KC Kilchis-Klickitat Association, 60 to 90% slopes
- KU Klickitat-Trask Association, 60 to 90% slopes
- RK Rock outcrop-Kilchis Association, 60 to 90% slopes
- VY Valsetz-Yellowstone Association, 3 to 60% slopes



TIMBER SITE CLASS V

- VZ Valsetz-Yellowstone Association, 60 to 90% slopes

**TIMBER SITE CLASS MAP**  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES  
OREGON  
OCTOBER 1978



LOCATION MAP

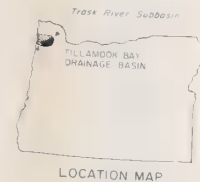


# Vegetative Cover and Land Use Maps





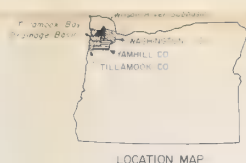




VEGETATIVE COVER AND LAND USE  
Open 75% low  
Shrub 50-75% low  
Forest 25-50% low  
75% low

VEGETATIVE COVER AND LAND USE MAP  
TRASK RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES  
OREGON  
AUGUST 1977  
SCALE 1:50,000





- VEGETATIVE COVER AND LAND USE
- Chaparral 20' - 30'
  - Chaparral 30' - 40'
  - Chaparral 40' - 50'
  - Chaparral 50' - 60'
  - Chaparral 60' - 70'
  - Chaparral 70' - 80'
  - Chaparral 80' - 90'
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  - Chaparral 680' - 690'
  - Chaparral 690' - 700'
  - Chaparral 700' - 710'
  - Chaparral 710' - 720'
  - Chaparral 720' - 730'
  - Chaparral 730' - 740'
  - Chaparral 740' - 750'
  - Chaparral 750' - 760'
  - Chaparral 760' - 770'
  - Chaparral 770' - 780'
  - Chaparral 780' - 790'
  - Chaparral 790' - 800'
  - Chaparral 800' - 810'
  - Chaparral 810' - 820'
  - Chaparral 820' - 830'
  - Chaparral 830' - 840'
  - Chaparral 840' - 850'
  - Chaparral 850' - 860'
  - Chaparral 860' - 870'
  - Chaparral 870' - 880'
  - Chaparral 880' - 890'
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  - Chaparral 930' - 940'
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  - Chaparral 950' - 960'
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  - Chaparral 980' - 990'
  - Chaparral 990' - 1000'



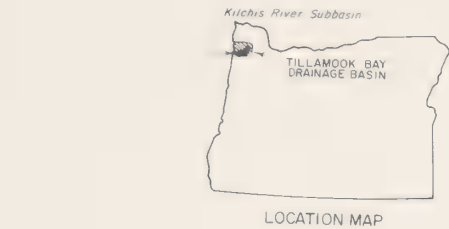
VEGETATIVE COVER AND LAND USE MAP  
WILSON RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

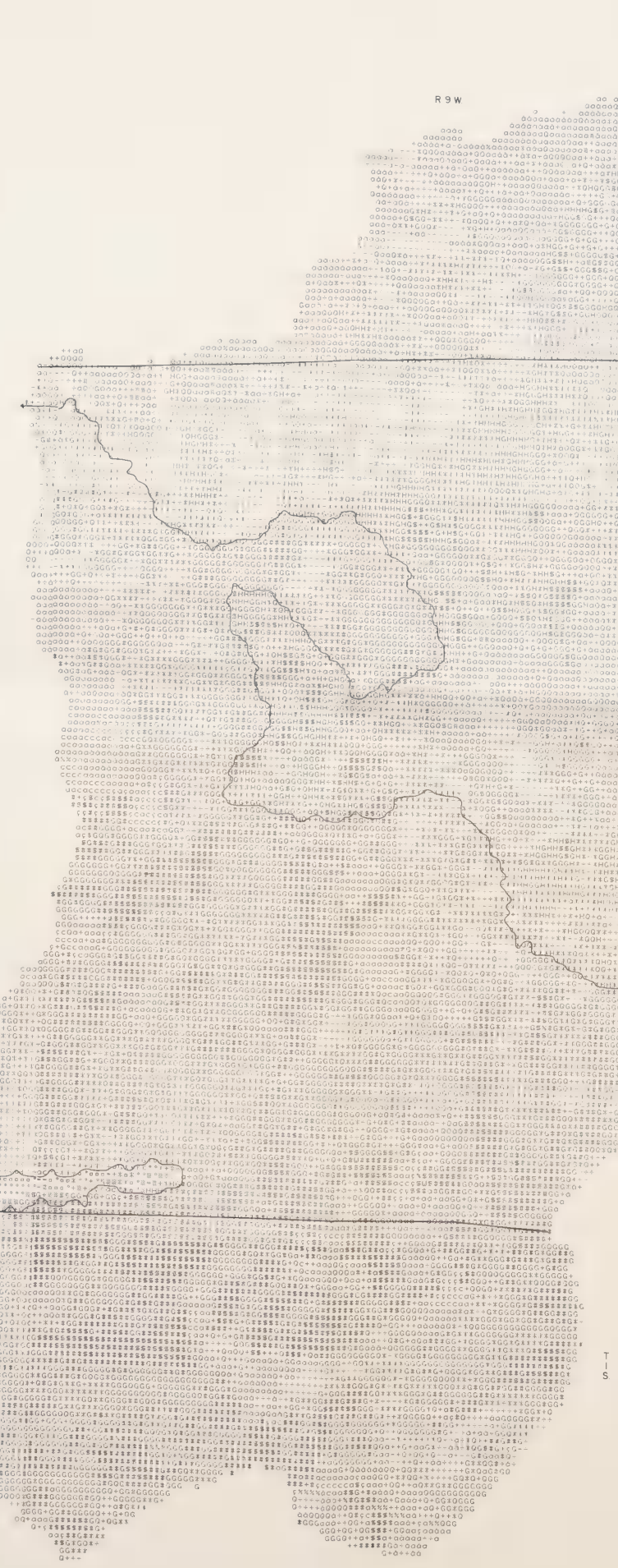
AUGUST 1977





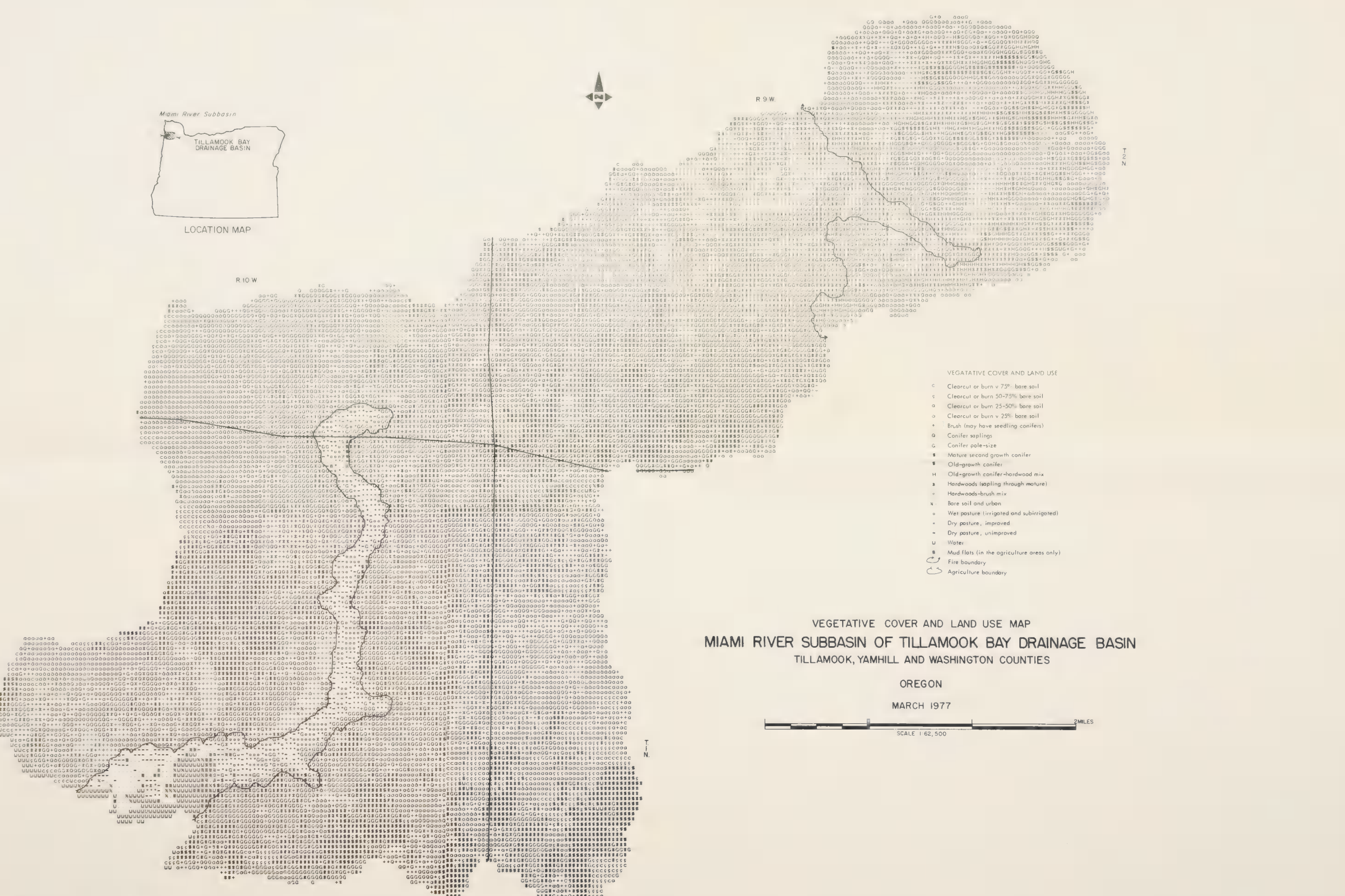


- VEGETATIVE COVER AND LAND USE
- C Clearcut at burn 75% bare soil
  - D Clearcut at burn 50-75% bare soil
  - E Clearcut at burn 25-50% bare soil
  - F Clearcut at burn 25% bare soil
  - G Blush (may have standing water)
  - H Canifer, sapling size
  - I Canifer, pole size
  - J Mature second growth canifer
  - K Old-growth canifer
  - L Old-growth canifer-hardwoods mix
  - M Hardwoods
  - N Hardwoods-brush mix
  - O Rock (in the forested areas only)
  - P Mud flats (in the riparian areas only)
  - Q Urban and bare soil
  - R Wet pasture (irrigated and subirrigated)
  - S Dry pasture, improved improved
  - T Dry pasture, unimproved
  - U Water
  - V Five boundary
  - W Agriculture lands boundary



VEGETATIVE COVER AND LAND USE MAP  
KILCHIS RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES  
OREGON  
MARCH 1977





Source: Base map prepared by SCS, WTSC Carto Unit from ERSAL-OSU Computer Center, compilation. U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

7-N-23986



## RECREATION RESOURCES

### GENERAL

Recreation is becoming an increasingly important industry in the Pacific Northwest. There seems to be no limit to the demand for recreational facilities and tourist accommodations -- and that is a potential problem. The Oregon coast, because of its richly endowed beauty and wealth of recreation opportunities, is attracting more and more people.

Average daily traffic from October to May increases drastically between June and September. When the salmon are running or there is a good minus tide for clamming, traffic counters and tempers are sent soaring to new highs. Delays of two hours and more are encountered at popular Tillamook Bay boat launching sites and the highways home are crowded with a seemingly unending stream of slow moving traffic.

Linked to heavy day usage by Willamette Valley residents is the demand by both Oregonians and out-of-state visitors for public overnight campgrounds. Nationwide studies indicate a tripling in outdoor recreation participation by the year 2000, but rank camping low on the list of user preferences (Table IV-11).

Table IV-11, USER PREFERENCE

<u>State Park Users in Area - 1964</u>	<u>Siuslaw National Forest Users - 1966</u>	<u>United States 1960</u>
1. Sightseeing	1. Camping	1. Swimming
2. Camping	2. Picnicking	2. Sightseeing
3. Swimming	3. Fishing	3. Picnicking
4. Picnicking	4. Hunting	4. Fishing
5. Fishing	5. Boating	5. Boating
6. Hiking	6. Swimming	6. Camping
7. Boating	7. Hiking	7. Hiking

Source: Recreation-Tourism - Central Oregon Coast, Bureau of Governmental Research and Service, 1969, P. 16

The rankings in Table IV-11 indicate that the Oregon coast is a mecca for campers due to the ocean influence and the excellent job the state and county have done in campground development, thereby resulting in a much higher ranking locally for overnight facilities. The Tillamook area has emphasized this aspect of its recreation resources by developing campgrounds, picnic areas, boat launch sites, and beach access throughout the coastal area.

The rate of growth for the western states is greater than for the nation as a whole. Also, the Willamette Basin population, which contributes heavily to Tillamook County recreational demands, is expected to grow at a faster rate than the state.

Projected population within Tillamook County is another measure of future recreational demands as shown on Table IV-12. The components of local population were analyzed in a recent publication concerning utility planning. This separated local permanent population from seasonal and tourist population, and will aid in determining the needs for recreational facilities.

Table IV-12, TILLAMOOK COUNTY POPULATION

	<u>Estimated - 1967</u>	<u>Projected - 1990</u>
Permanent Population	18,000	20,600
Seasonal Population	5,500	8,200
Tourist Population	5,700	15,200
	29,200	44,000

Source: Comprehensive Water and Sewerage Planning Study-Tillamook County, Oregon: Volume 1, Planning Background, CH<sub>2</sub>M, revised 7-31-69, P. 20.

Sports fishing and the taking of shellfish account for much of the recreational activity in the basin. Anadromous fish, including chinook, silver, chum, salmon, and steelhead are taken from the bay, the five major rivers, and off-shore fishing grounds. In addition, resident stocks of trout occur in small lakes and streams throughout the basin. For salmon fishing in the ocean there is the exciting prospect of joining dorymen at Barview and launching directly through the surf. Fishing boats cross the bar at Tillamook headed for offshore fishing grounds.

All of the foregoing serve as general indications of what the basin might expect future recreational demands to be. Satisfying those demands might require additional conversion of the coastal area, with expanded and new campgrounds, more angler access and beach access points, an accelerated road and highway improvement program, and a more rapid development of shore and hillside lands for summer homesites. Public facilities and services would need to be expanded and increased to minimize the adverse effects of increased human occupation of the land. Care must be taken in developing recreation-oriented uses or the very assets that the area boasts of could be severely damaged -or lost.

Developed recreation resources exist primarily to serve the public. Campgrounds and boat launching sites are emphasized in development programs of most agencies with recreation resource management responsibilities. There are 16 boat launching sites, 11 campgrounds, and 7 picnic sites in the area. The activities and facilities available at the campgrounds and picnic sites are summarized on Table IV-13.

Sometimes overlooked is the extent to which private enterprise provides recreation facilities. For example, about half of the marinas, docks, launch sites, etc. available to the public in Tillamook area are privately owned and operated. Major timber companies also help by providing campgrounds for public use as well as opening selected portions of their land to permit hunting and fishing. Based upon the multiple use concept, these facilities and policies allow recreation enjoyment of areas where tree farming and sustained yield are practiced.

#### BAYOCEAN PENINSULA

The Bayocean Peninsula on Tillamook Bay is of particular interest to the county in that much of the property on this sandspit is county-owned due to tax foreclosures. Any future development should avoid the mistakes made on the Bayocean Peninsula that caused the community of Bayocean to be cut off from the mainland due to a breaching of the spit, with subsequent abandonment of property and the resultant tax delinquency. There still are some scattered private ownerships that will need to be taken into account when detailed plans are made for the spit.

Figure IV-11 is a sketch of a typical dune cross-section similar to some areas of Bayocean Peninsula. It will serve as a model for a brief discussion of planning considerations related to various parts of a dune system. For a more detailed discussion see *Beaches and Dunes of the Oregon Coast*, USDA-SCS-March, 1975.

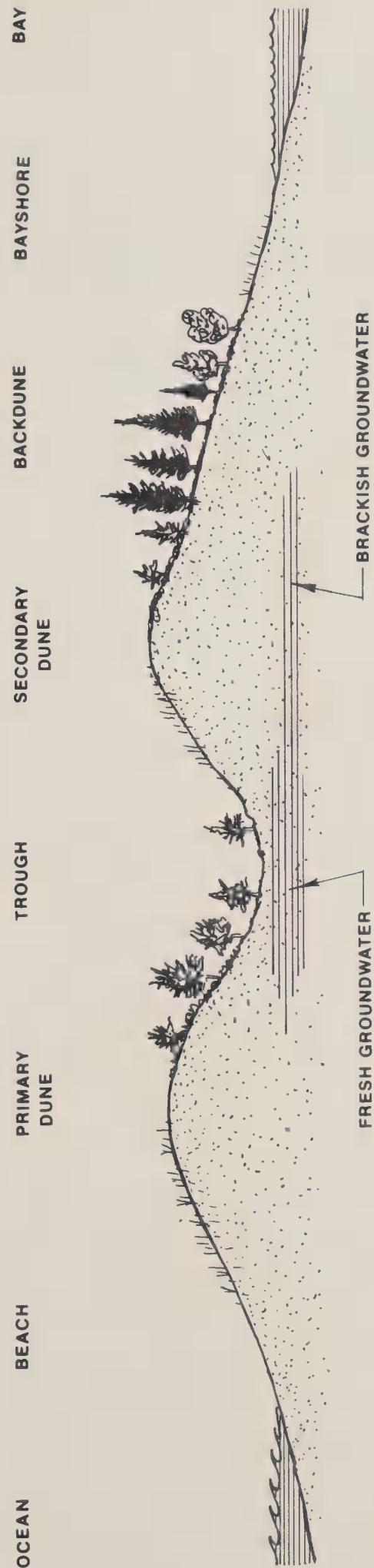
The first zone of a typical dune is the ocean beach, an area highly tolerant of human use for walking, fishing, sunbathing, swimming, and surfing, but essentially unsuited for uses other than public recreation. This is the so-called "dry sand" area lying seaward of the vegetation line in which Oregon statutes prohibit (below 16 feet elevation) any construction without a permit.

The next zone is the primary dune which is absolutely intolerant to trampling, and a zone in which no development should be allowed. This is the first line of defense against storms and floods and must not be breached.

Table IV-13 --RECREATION SITES AND AREAS, TILLAMOOK BAY DRAINAGE BASIN, OREGON, 1975

Site/Area Name	Ownership	Acres	Facilities			Activities <sup>1/</sup>
			Camping	Picnicking	Boating	
			Units	Units <sup>2/</sup>	Ramps	
Wilson River Wayside	State	789		24		P, F, S
Wilson River Picnic Area	Private	15				F, S, P
Jones Creek State Park	State	56	75			F, C, S, H
Keenig Creek State Park	State	22	38			F, C, S, H
Fern Rock Wayside	State	2/		3		F, P, S
Kilchis River Recreation Area	County	2,500	30		X	F, S, SW, H, C, B
Trask River State Park	State	39	100			F, S, H, C
Barview Jetty Park	Tillamook Co.	300	164			F, OB, D, V, SW, C, P
Tillamook River Wayside	State	8		6		P, F, S
Goodspeed Park	Municipal	2	2/			
Marine Park	Municipal	1/2	2/			
Liberty Park	Municipal	4	2/			
Bay City Park	Municipal	2/	2/			
Wilson River Co. Park	County	40	2/			
Munson Falls Park	County	25	2/			
Peninsula	State	20	6			F, C, H, S
Diamond Mill	State	10	15			F, C, H, S
Elk Creek	State	9	15			F, C, H, S
Camp Brown	State	20	15			F, C, H, S
<u>1/</u>						
History	H		Swimming			
Lake - Stream	L-S		Hiking			
Nature Study	N		Picnicking			
Ocean Beach	OB		Camping			
Rockhound	R		Hunting			
Sand Dunes	D		Boating			
Scenic Views	V		Geology			
			Fishing			
	SW					
	HK					
	P					
	C					
	HU					
	B					
	G					
	F					

2/ Data Unknown



Typical Dune Cross Section

Fig. IV - 11



The next zone is the trough which is more tolerant of development. However, any drawdown of ground water supply through the use of shallow wells or the diversion of rain water from roofs and paved parking areas into drains and piped waste-water systems, could upset vegetation due to the altered water table and set the stage for reduced stability in the primary dune.

The secondary dune is the second line of defense and is as vulnerable as the primary dune. The backdune, however, is a more permissive location and may be the most suitable area for some development. Though development should not occur at the narrowest portion of the dune, the wider, flatter, and better protected portions could offer recreational opportunities for water-oriented uses as well as some shore developments.

Human occupation should be regulated so that ground water sources not be lowered to a critical level and that sewage not be allowed to seep into the bay. This may mean that a peninsula community water supply from other sources will be required and that a sewerage system complete with proper treatment should be made a part of any plan for development.

Closing the breach on the Bayocean Peninsula by a diking project conducted by the Corps of Engineers points out another way in which dune stabilization can be accomplished. Road access, if located on the bay side and constructed on top of an artificial dune, can prevent further breaching. Road fill material should generally be dredged from the ocean side, not the bay side where the shellfish beds may be disturbed.

The jetties at the mouth of Tillamook Bay probably influence the stability of the sandspit. See Inventory, Oregon Coastal Shoreline Erosion, State Soil and Water Conservation Commission, September 1978 for a more detailed discussion.

## HISTORICAL RESOURCES

Tillamook Drainage Basin has many operating examples related to its historical development. Many old dairy barns from the last century are still used today much as they were when first built. The famous Tillamook Cheese Factory is visited by nearly all tourists who come to the basin.

The Pioneer Museum in Tillamook contains a wide variety of natural and historical displays pertaining to the northwest as well as the local Tillamook County area. Its natural history exhibits are especially noteworthy and are considered to be among the most outstanding in the Pacific Northwest. Financial support for the museum has come largely from local sources.

## ARCHEOLOGICAL RESOURCES

Little is known of the prehistory in the Tillamook region. In the late 1950's the first archeologic excavations were begun and these provide much of the knowledge of the region.

Archeological evidence indicates firmly established cultures on the shores of Columbia River 9,000 years ago. Archeologists believe the Coast Salish influenced development in the Tillamook area during the 1400's; by 1670, the Northwest Coast culture was complex and fully developed. Villages were composed mainly of long, rectangular cedar plank dwellings, often sheltering two or three families. The Indians depended upon the bay area for food, particularly salmon. Ten village sites have been identified. The main village, Kil-har-hurst, is almost completely covered by the present town of Garibaldi. In historic times, remnants of the Tillamook Nation lived in Squaw Town, a settlement a mile south of the Miami River.

The approximate locations of remaining archeological sites are shown in Figure IV-12. Most of these sites have been destroyed; however, Netarts Landing, an important canoe landing area for north-south travelers, and the village, Tow-er-gust-tons have been subjected only to natural forces. A known site on the Bayocean Peninsula was destroyed in 1952 when a storm reached the spit.

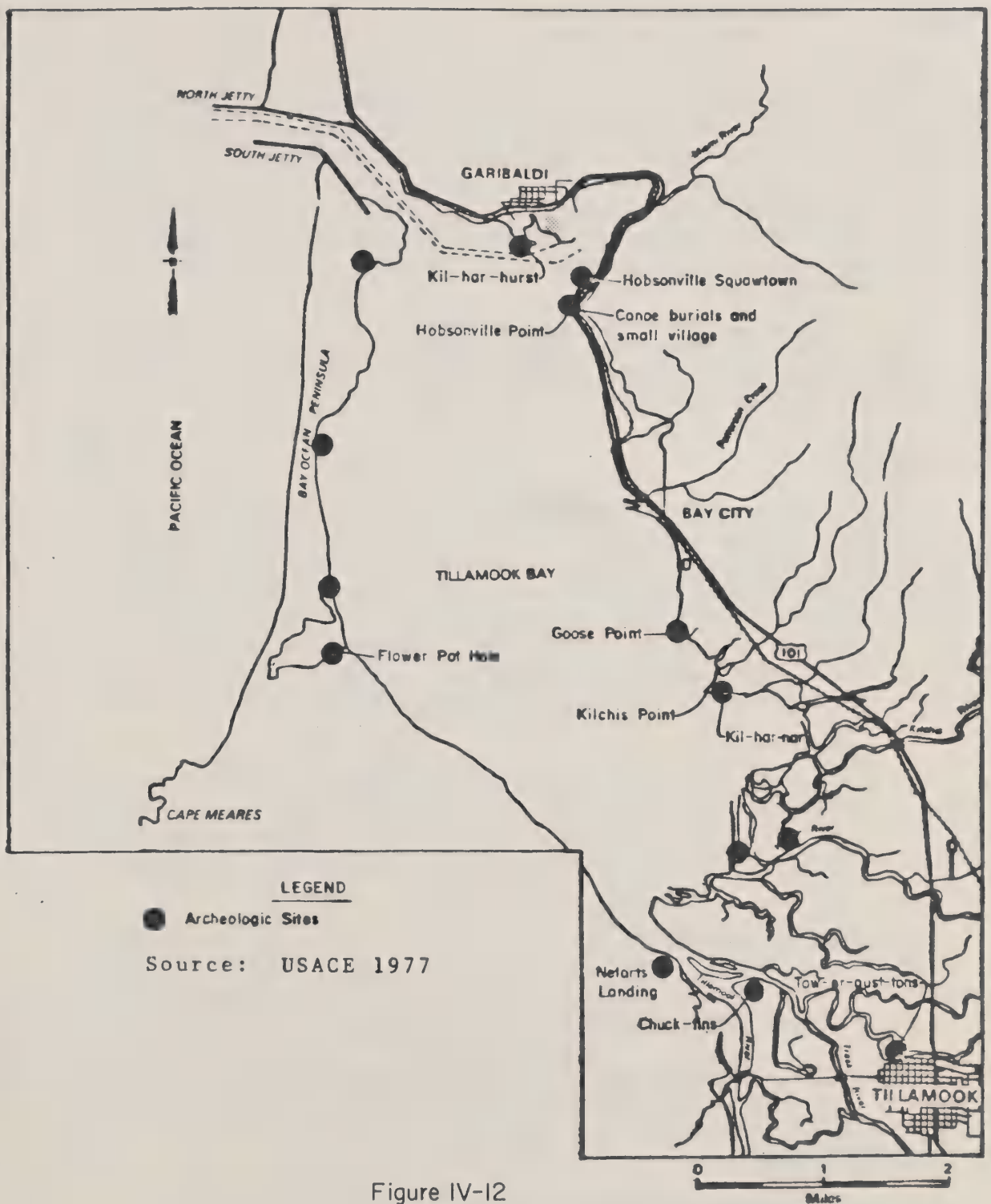


Figure IV-12

## ARCHEOLOGIC AND HISTORIC SITES

## FISH AND WILDLIFE RESOURCES

### GENERAL

The primary concern of this Study is sedimentation in Tillamook Bay. The fisheries and shellfisheries are directly affected by sedimentation. Human activities in the estuary have increased in recent years and will probably continue to expand in the future. Many of these activities will occur along shorelines or in shallow waters. Such shallow areas are often necessary to many important fish and shellfish species and the food organisms on which they depend. Misuse of other estuaries in the past has reduced their productivity for fish and wildlife and diversity for human use.

The Oregon Fish Commission conducted an inventory of freshwater and marine resources in Tillamook Bay in 1971. The following fish resources data is from that study.

### FISH RESOURCES

Estuaries are among the most productive ecosystems in the world, and Tillamook Bay has been one of the most important producers of fish and shellfish in Oregon. Sediment deposition has had both beneficial and detrimental effects on these resources. The nutrients so vital to a highly productive ecosystem are replenished yearly by soils eroded from the uplands. Excessive erosion and sedimentation results in covering up nutrients so that they are not available. Sediment also smothers eel grass beds, shellfish beds, and the larvae of fish and shellfish.

Eel grass beds are found scattered throughout Tillamook Bay (See Fisheries Resources Map Sheet 2 of 2). These beds are usually found in areas of shallow water and high salinities. Clams and other important marine fauna are usually an integral part of the eel grass beds.

More than 80 percent of the oysters grown in Oregon come from Tillamook Bay. The Fisheries Resources Map (Sheet 1 of 2) shows the commercial oyster leases, totaling 2,285 acres. An estimated 3,300 acres of Tillamook Bay are considered suitable for oyster culture.

The food production areas, fish feeding areas, and fish migration routes in Tillamook Bay are shown on the Fisheries Resources Map (Sheet 2 of 2). Also outlined on the Map (Sheet 1 of 2) are the known herring spawning areas.

The productivity of estuarial areas is related to length of shoreline, depth of water, and geographical location. Within each estuary, tidelands are generally more productive than deep water

# FISHERIES RESOURCES TILLAMOOK BAY

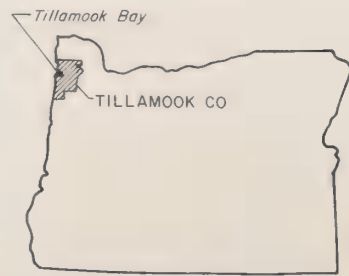
## TILLAMOOK BAY DRAINAGE BASIN

### OREGON

JULY 1977  
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LEGEND  
 Clam Beds

LEGEND  
 Commercial Oyster Leases, 1971  
 Known Herring Spawning Areas, 1971



LOCATION MAP



# FISHERIES RESOURCES TILLAMOOK BAY

## TILLAMOOK BAY DRAINAGE BASIN

### OREGON

JULY 1977

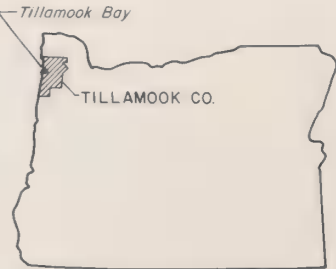
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#### LEGEND

Principal Boat Fishing Areas, 1971

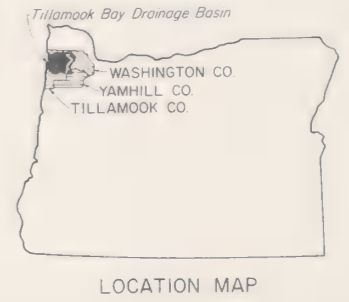
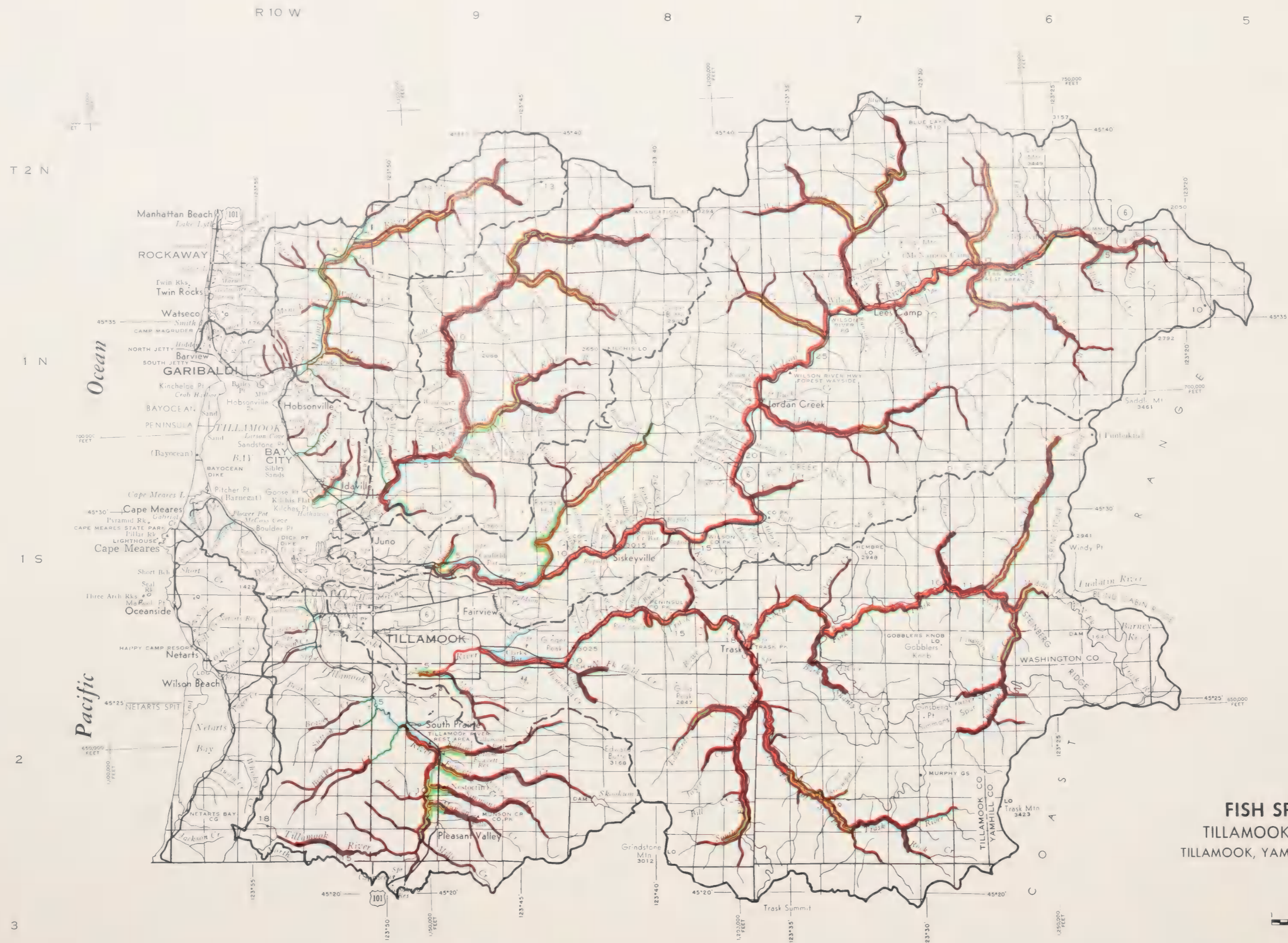
- Crab (Jan.-Dec.)
- Salmon (May-Nov.)
- Perch (May-July)
- Rockfish (May-Aug.)
- Flounder (May-June)
- Searun Cutthroat Trout (July-Oct.)



LOCATION MAP

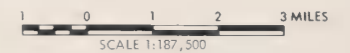






# **FISH SPAWNING AREAS** **TILLAMOOK BAY DRAINAGE BASIN** **TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,** **OREGON**

MARCH 1977





channel areas. Tidelands are also the primary sediment deposition areas. The production of food organisms in Tillamook Bay occurs throughout the entire estuary. These food organisms include the bacteria, microscopic phytoplankton and other algae, zooplankton, small crustaceans, mollusks, annelids, and fish which are all important in the estuarine food chain.

The fish feeding areas of Tillamook Bay (for finfish and shellfish) include all areas of the estuary under tidal influence. Tideflats as well as deep-water channels and rocky areas provide a variety of rearing habitat. Species of fish, numbers, and distribution within each area are generally related to type of food organisms, bottom type, water depth, and water quality. Forty-five species of fish have been identified in Tillamook Bay.

Fish and shellfish typically found associated with tideflats include flounder, sole, perch, rockfish, salmon, crabs, shrimp and soft shell clams. In addition to those species found on tideflats, herring, anchovy, and smelt reside in the estuary channels; period of residency is dependent on species, season, and location.

Rocky areas in Tillamook Bay are the preferred feeding and rearing areas of perch, rockfish, greenling, and cabezon. These fish reside near the jetties and rock groins of the lower bay.

Fish migration routes are those areas traveled by fish to and from spawning, feeding, or rearing areas. Fish migration routes through Tillamook Bay are as varied as the species that use them. Species and age class of fish, season, water depth, and water quality all play an important role in fish migration patterns.

The use of channel areas throughout the estuary by salmon, trout, perch, flounder, and baitfish is well known. In addition, during high tides, these same fish frequently swim across tideflats to reach their destination.

From January through March, herring eggs can be found adhered to pilings, rocks, or eel grass in those areas outlined on the Fisheries Resource Map (Sheet 1 of 2). More complete observations in the future will no doubt reveal other areas used by these fish.

Nearly every stream segment in the basin provides spawning and rearing habitat for some species of anadromous fish. Spawning areas are displayed on the Fish Spawning Map.

#### WILDLIFE RESOURCES

There have been many adverse as well as beneficial impacts of the fires and subsequent logging activity on wildlife populations. The dense forest dwellers such as the spotted owl suffered drastic reductions in its habitat.

Wildlife species which benefitted most from the fires are those which require forest-edge-type habitat such as Roosevelt elk, and black-tailed deer. Much of the burn was invaded by forbs, grasses, and brush species. This provided ideal forage and when coupled with the unburned islands and new forest cover which developed, provided ideal habitat allowing rapid deer population growth. The population of these species have since peaked out. Black-tailed deer populations are now much reduced while elk numbers have stabilized.

The habitat can be divided into feeding areas and resting areas.

There are 230,960 acres in the basin which provide good cover for escape, resting, and breeding of larger wildlife species with 41,450 acres also providing limited forage. Primary forage is available on 88,780 acres. The primary forage areas also provide limited cover.

The current habitat situation will remain somewhat stable. Timber harvest will provide a constant forage-cover ratio much as it is today. This will favor wildlife which readily adapt to rotation of feeding and resting areas. Species such as the spotted owl will probably continue to be limited.

Small populations of game birds includes mountain quail, blue and ruffed grouse, and band-tailed pigeon. These receive light hunting pressure during the fall. Waterfowl seasonally inhabit the estuary and sloughs.

Non-game animals include beavers, muskrats, otters, minks, marten, racoons, skunks, coyotes, bobcats, nutrias, rabbits, squirrels, mountain beavers and many types of rodents including moles. Non-game birds include hawks, owls, crows, ravens, herons, and a variety of song birds. Populations of ocean and shore birds are outstanding and contribute greatly to natural and scenic areas.

## WATER RESOURCES

### TILLAMOOK BAY

The major body of water within the study area is Tillamook Bay Estuary. The bay is about 6 miles long in a southeast to northwest direction, 2 miles wide, and less than 6.5 feet in average depth. The elliptical-shaped area is separated from the Pacific Ocean by a long, narrow sandspit, Bayocean Peninsula, that extends northward from Cape Meares. Access to the ocean is through a 1200-foot-wide channel at the north end of the bay. The entrance is protected from winter storms by two rock jetties. The south jetty was constructed primarily for this purpose and the hope that it might also alleviate shoaling at the entrance. However, because of littoral drift patterns, jetty shoaling in the entrance results in navigation hazards. Periodic but limited dredging operations by the U.S. Corps of Engineers have been necessary to maintain an 18-foot-wide channel into Tillamook Bay from the bar to permit access by fishing boats and commercial barges to the City of Garibaldi. At one time, access to the south end of the Bay was comparatively easy for tug boats, barges, etc. However, continued deposition of sediment has reduced this area to a series of sand bars and several very shallow and narrow channels.

### RIVERS AND STREAMS

Tillamook Bay is the termination point for a radial-shaped network of five major rivers which originate in the upper reaches of the basin (see Study Area Map). These are, from north to south, the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Several small streams also flow from the rolling hills adjacent to the margins of Tillamook Bay.

The smallest of the tributaries, the Miami River, flows south, draining an area of 39.9 square miles, and enters the north end of the bay. Five miles to the south, the Kilchis River with a drainage area of 73.3 square miles enters the bay from a north-easterly direction. The largest of the five drainages, the Wilson River with its many upland tributaries covers 34.5 percent of the total basin. It flows directly west to the bay from a drainage area of 196.1 square miles. The Trask River with a coverage of 31.2 percent of the basin, flows west to northwest and divides the basin area between the Wilson and Tillamook Rivers. Like the Wilson River, it has many upland tributaries flowing from a watershed area of 176.7 square miles. The fifth major drainage, the Tillamook River, has a low gradient. It has numerous tributaries and flows northward to the bay from a 67.4 square mile drainage area.

## URBAN AND OTHER RESOURCES

Land classified in this category includes areas other than cropland, permanent pasture, brush and cutover land and forest lands. It amounts to 12,867 acres or 3.5 percent of the total basin area. Urban and industrial areas account for 1,730 acres. Roads and railroads comprise 29,400 acres or 8.0 percent of the land classified as "other resources". Approximately 10,980 acres, or 3.0 percent of this classification, includes all bodies of water--namely Tillamook Bay and its five major tributaries.

## LAND OWNERSHIP

The catastrophic fires of 1918 through 1951 have also affected the land ownership of Tillamook Drainage Basin. Repeated burns destroyed valuable stands of timber, leaving many landowners in financial despair, while others lacked resources to reforest the lands. Many thousands of acres were turned back to the county in lieu of paying the taxes. The county, in turn, signed the lands over to the State of Oregon.

The state is now the principal landowner in the Study area with 235,190<sup>1/</sup> acres. The balance includes 10,130 acres in county and municipal; 16,720 acres in federal; 74,950 acres in timber industry; and 26,530 acres in small private and other ownerships. (See Land Ownership Map.)

Federal lands include 15,800 acres of public domain and Oregon and California Railroad (O&C) lands administered by the Bureau of Land Management (BLM). Lands of the defunct O&C have reverted to federal ownership. The remaining 920 acres in federal ownership are national forest lands administered by the Forest Service (FS), through the Hebo Ranger District of the Siuslaw National Forest. These ownerships are summarized in Table IV-14.

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<sup>1/</sup> The State of Oregon claims all navigable waters in the state. These are included with the exception of where these waters cross federal lands.

Table IV-14--LAND OWNERSHIP, USE, AND COVER

Landowner	Land Cover and Use (Acres)					Total
	Forest Land <sup>1/</sup>	Cropland <sup>1/</sup>	Urban <sup>1/</sup>	Water	Rock & Sand	
Federal						
Dept. of Agriculture						
National Forest	920	- -	- -	- -	- -	920
Subtotal Dept. of Agr.	920	- -	- -	- -	- -	920
Dept. of Interior						
Public domain	15,480	- -	- -	40	280	15,800
Subtotal Dept. of Int.	15,480	- -	- -	40	280	15,800
Total Federal	16,400	- -	- -	40	280	16,720
State of Oregon	220,840	- -	- -	10,770	3,580	235,190
County and municipal	5,860	2,010	1,730	170	360	10,130
Timber industry	74,450	500	- -	- -	- -	74,950
Other	5,500	21,030	- -	- -	- -	26,530
Total	323,050	23,540	1,730	10,980	4,220	363,520

<sup>1/</sup> These areas include rights-of-way through the resource use area.



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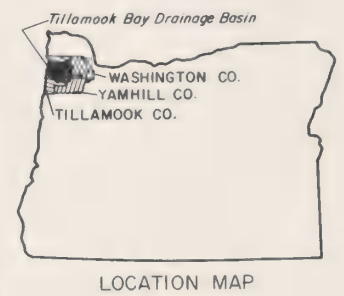
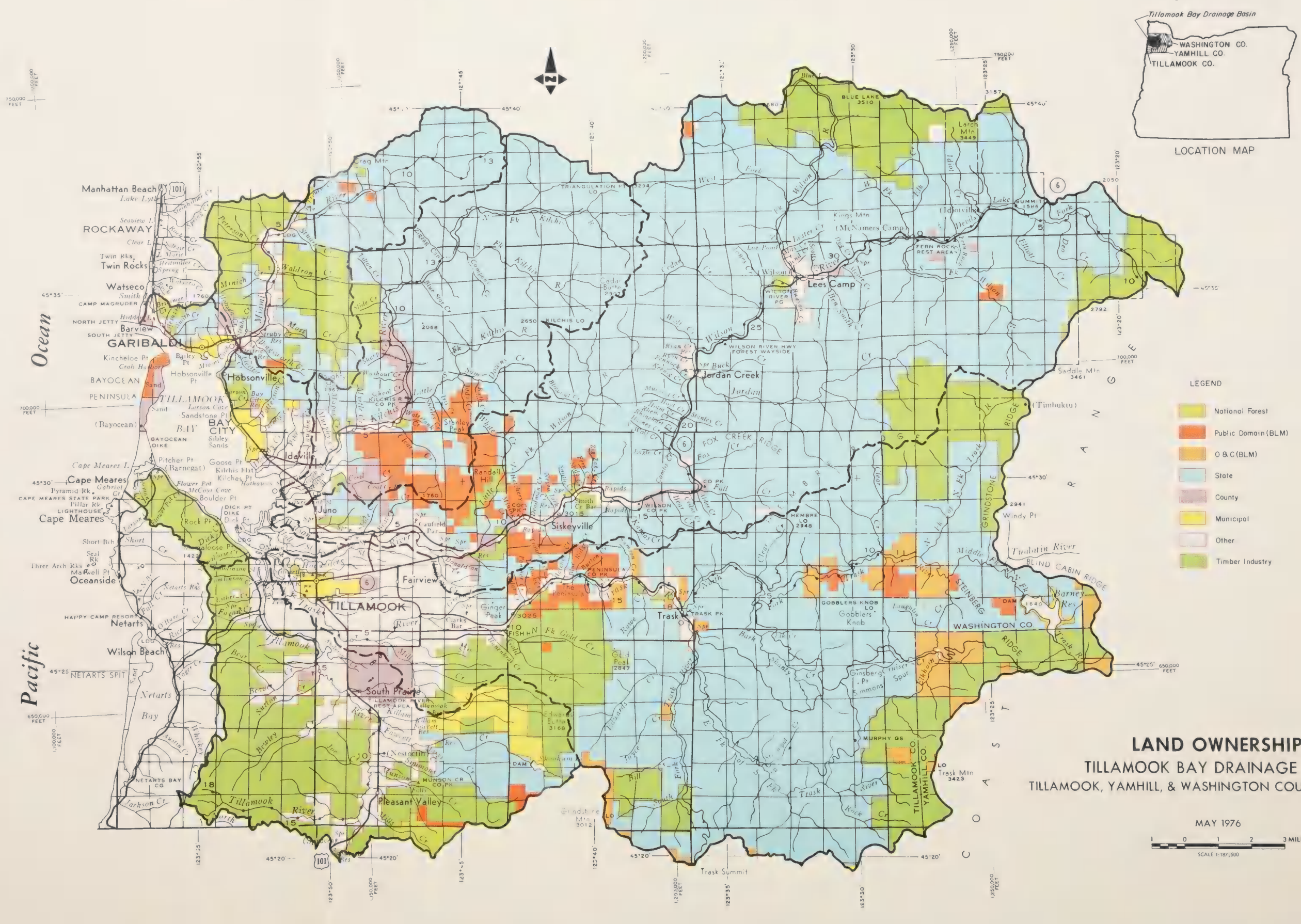
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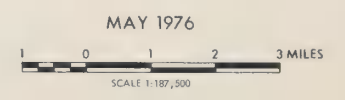
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LEGEND

- National Forest
- Public Domain (BLM)
- O & C (BLM)
- State
- County
- Municipal
- Other
- Timber Industry

LAND OWNERSHIP  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON





## CHAPTER V

### ECONOMIC DEVELOPMENT



# ECONOMIC DEVELOPMENT

## GENERAL

The economy of the Tillamook Bay Drainage Basin area is based primarily on forestry, agriculture, and recreation or tourism.

Population is essentially rural in character with only 22 percent classified as urban. Annual unemployment has averaged about 7.5 percent of the labor force in recent years. Average family income was \$9,401 in 1970 for county residents, below the average for both the U.S. and Oregon.

## POPULATION

Population trends are shown in Figure V-1 for Tillamook County and Tillamook City. County population peaked in 1960, declined during the mid-sixties, and has gradually increased during the early seventies.

Population of the Tillamook Bay Drainage Basin study area is about 70 percent of that of the county or 12,715 persons in 1970. The heaviest population densities are concentrated in towns and rural areas adjacent to Tillamook Bay. The towns of Tillamook, 3,968; Garibaldi, 1,083; Bay City, 898; and Rockaway, 665, accounted for 52 percent of the total study area population in 1970.

While overall county population decreased by about six percent during the last census decade, the number of people 65 years and over increased by 26 percent from 1,894 in 1960 to 2,395 in 1970. For various socio-economic reasons, younger age groups have tended to migrate out of the county.

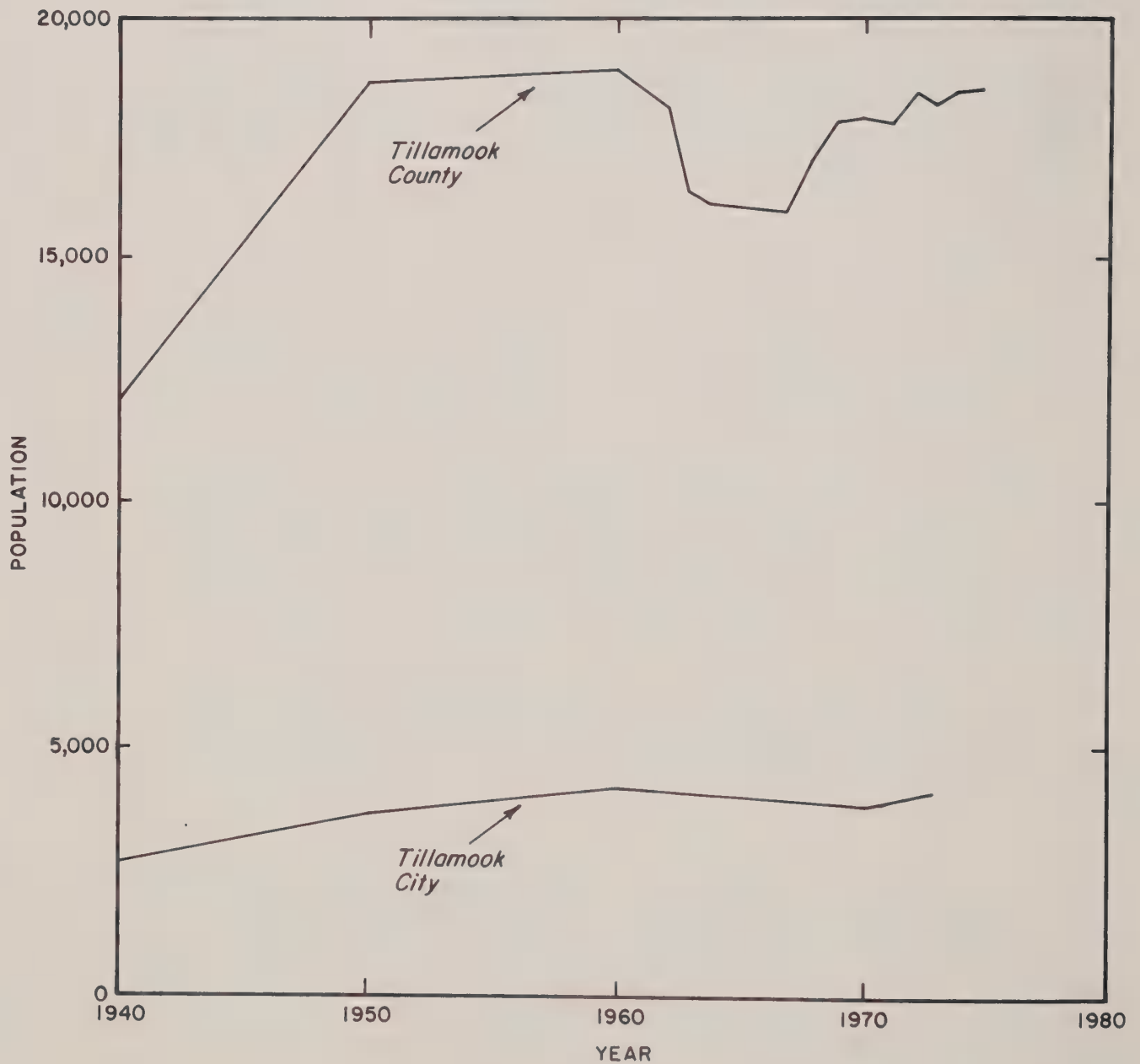
In addition to resident population, several thousand non-resident tourists visit the area during the summer tourist season. Peak seasonal non-resident population was estimated at 9,860 persons for Tillamook County in 1973.<sup>1/</sup> Tourists bring in recreation dollars. But they also require camping sites, roads, picnic areas and they directly increase the requirements for water systems, sewerage treatment, law enforcement, and other public services.

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<sup>1/</sup> Estimated nonresident population (tourists) was developed by the Oregon Projections Sub-Work Group for use by the Oregon State Water Resources Board (now the Oregon State Water Resources Department.)

Figure V-1

## POPULATION-TILLAMOOK COUNTY, OREGON



Center for Population Research and Census - Portland State University

## EMPLOYMENT

Total Tillamook County employment for 1970 was 6,230 persons (Table V-1). The lumber and wood products industry is the major employer, with about 1400 people in 1970. Employment increased 65 percent from 1940 to 1950 and has since decreased. The largest employment decreases occurred in agriculture, forestry, fisheries, and the lumber and wood products sectors, all of which are basic industries to Tillamook's economy. Some retail trades, the medical and professional services, and public administration sectors experienced increases in employment from 1950 to 1970, partially offsetting the losses in basic industries. Despite offsetting employment gains, total county employment decreased by 10 percent over the 20-year period.

Average annual unemployment in Tillamook County ranged between 5.9 and 10.8 percent from 1970 to 1974. Average monthly unemployment over the same time period ranged between 4.2 percent for September 1972 and 18.6 percent for December 1974. The wide range in monthly unemployment is indicative of the highly seasonal nature of the major industries: Forestry, fishing, recreation, and agriculture.

Table V-1 Employment, Tillamook County, 1940, 1950, 1960, 1970

Industry	Year			
	1940	1950	1960	1970
Agriculture, forestry & fisheries.....	1,126	1,303	1,002	762
Contract construction.....	241	412	243	366
Manufacturing:				
Food.....	139	202	253	143
Lumber & wood.....	979	2,159	1,792	1,404
Printing & publishing.....	29	48	34	33
Other manufacturing.....	30	54	48	169
Transportation.....	101	139	159	108
Communications.....	22	75	75	46
Utilities.....	42	110	110	127
Wholesale trades.....	76	164	68	116
Retail food stores.....	144	212	181	132
Eating places, bars, taverns.....	94	211	226	311
Other retail trades.....	241	455	535	557
Finance, insurance, real estate.....	55	128	160	147
Hotels, personal services.....	227	272	235	259
Private households.....	130	104	120	75
Businesses & repair services.....	92	141	154	139
Entertainment, recreation.....	33	69	24	46
Medical, professional services.....	279	497	750	985
Public administration.....	114	194	236	289
Other employment.....	10	5	8	16
TOTAL.....	4,204	6,954	6,413	6,230

U.S. Department of Commerce, Census of Population.

## INCOME

Average per capita income of county residents in 1969 was \$2,843 (Table V-2). This was lower than the per capita income for the adjacent counties of Clatsop and Lincoln, and well below Oregon and the United States.

According to the federal definition of poverty, 11.1 percent of all families in Tillamook County in 1970 earned incomes below the poverty level. Tillamook was ranked with the ninth highest poverty level of all counties in the state. Approximately 1,795 persons were living at or below poverty levels.

Table V-2--Personal Income Comparisons, Tillamook County, 1969

Area	Per Capita Income	Oregon Relative Per Capita Income	Family Mean Income
Tillamook County.....	2,843	.90	9,401
Clatsop County.....	3,150	.996	10,335
Lincoln County.....	2,897	.92	9,031
Oregon.....	3,163	1.00	10,695
United States.....	3,139		9,590

Source: Oregon Coastal Area, etc.

## MAJOR ECONOMIC ACTIVITIES

The predominant economic activity in Tillamook County is the timber and wood products industry. In 1972, 35 firms were directly involved in the logging or processing of timber and lumber products. Other principal economic activities include dairying, commercial fishing and seafood processing, and recreation-related enterprises.

The value of Tillamook County gross outputs, by economic sector, was estimated for this study. The wood products industry which includes logging, sawmill and plywood operations, timber holdings, and associated service activities account for about 43 percent of total gross county output. The agriculture and food processing sectors are composed primarily of the dairy industry, and together make up about 17 percent of total county output. Remaining gross county output, 40 percent, stems from the construction, transportation and utilities, manufacturing, trades, services, and seafood sectors.

Table V-3, Total Estimated Gross Output by Major Economic Sector  
Tillamook County, Oregon, 1972

Major Economic Sector	Gross Output
	<u>Thousand dollars</u>
Agriculture.....	13,100
Wood products.....	71,700
Commercial seafoods.....	300
Construction.....	4,700
Food processing.....	15,400
Transportation & utilities.....	10,900
Manufacturing.....	5,700
Wholesale & retail trades.....	11,100
Finance, insurance & real estate.....	16,800
Services.....	15,300
TOTAL.....	165,000

The value of gross outputs shown in Table V-3 were the result of an input-output (I-O) model constructed of the Tillamook County economy for this study. This model can be used to estimate dollar impacts of economic changes on all of the interrelated sectors of Tillamook's economy.

The Tillamook model was tested in a trial run to analyze the economic effects of three types of public service funding. For this example, the levels of funding were:

Hospital remodeling	\$773,000
Public service (CETA)	327,500
Flood disaster relief	<u>1,800,000</u>
TOTAL	\$2,900,500

Analysis of these funds through the use of the Tillamook model showed the largest impacts to be on the construction industry (Table V-4). This is to be expected since a large share of the funds were used in the construction industry.

Table V-4 Total Estimated Gross Output by Sector After  
Incorporating Public Service Funds  
Tillamook County, Oregon

Major Economic Sector	Gross Output
	<u>Thousand dollars</u>
Agriculture.....	13,100
Wood products.....	71,800
Commercial seafoods.....	300
Construction.....	7,200
Food processing.....	15,400
Transportation & utilities.....	10,900
Manufacturing.....	5,700
Wholesale & retail trades.....	11,300
Finance, insurance & real estate.....	16,900
Services.....	<u>15,600</u>
TOTAL.....	\$168,200

The difference between total gross outputs in Tables V-3 and V-4 is 3.2 million dollars. This is \$300,000 more than the amount originally incorporated into the model. The additional \$300,000 represents interdependence of the directly-impacted sectors with other sectors of the economy.

It should be pointed out that the model has some limitations. Three limitations have to do with data availability, aggregation problems, and the static (single year) nature of the model. But I-O analysis also has many advantages. It requires that attention be given to all sectors of the economy of an area. It is uniquely adaptable to computers and it is consistent in the sense that solutions of demands and expenditures will add up to a total gross product.

## CHAPTER VI

### EROSION & SEDIMENT YIELD STUDIES & SURVEY PROCEDURES



# EROSION & SEDIMENT YIELD STUDIES & SURVEY PROCEDURES

## SURVEY PROCEDURES

### GENERAL

No previous detailed erosion and sediment yield studies have been made on agricultural land in the basin. However, water quality sampling to provide sediment load data has been in progress on four of the five tributary drainages for the past two years. Laboratory analysis was completed by the Department of Environmental Quality but no detailed interpretation of the results was available prior to implementation of this study.

### AGRICULTURAL LANDS

Inventory and analysis of erosion and sediment on agricultural lands involved two facets--sheet and rill erosion and streambank erosion. Evaluation of sheet and rill erosion initially involved the determination of the total acres of each soil type within the boundaries of each of the five tributary drainages. This was completed by planimetry of each soil component as mapped by the Soil Conservation Service on 1953 aerial photographs. This data was correlated with visually selected field sites based on degree of slope and current land use. The Universal Soil Loss Equation (USLE) was then applied to this data to determine the degree of sheet and rill erosion which could be expected to occur annually within each selected site area. It was then expanded to similar areas in other parts of each drainage. Consideration was also given to overbank flooding which, due to variable velocities, contributes to sheet and rill erosion as well as sediment deposition on farmlands, roads, etc. Based on the results obtained from using the USLE and a field judgment of sediment delivery, an estimate was made of the total amount of sediment which could be expected to reach each tributary drainage and Tillamook Bay.

Sediment deposition on farmland was quite evident, particularly in areas adjacent to the stream channel in four of the five drainages included in this study. Samples were taken of both the depositional sediment and the original underlying topsoil at the same location (See Soil Sample and Erosion Plots Map). A complete analysis was made on each sample with regard to nutrient deficiencies, laboratory work for which was done by Oregon State University Soil Testing facility at Corvallis, Oregon (See Table VI-1). The tests on these random soil samples indicate that the sediment deposits have a pronounced effect on various element deficiencies within the underlying soil profile, particularly nitrogen and organic matter content.

TILLAMOOK BAY DRAINAGE BASIN  
EROSION AND SEDIMENT STUDY

NUTRIENT ANALYSIS  
TOPSOIL AND SEDIMENT DEPOSITION SAMPLES

TABLE VI-1

Sample	Sample depth	Lab.	pH	P (ppm)	K (ppm)	Extractable cations				Salts (mmhos/cm)	Org. Matter %	Total Nitrogen %	CEC (meg/100g)
						Ca (meg/100g)	Mg (meg/100g)	Na (meg/100g)	B (ppm)				
M-Sed-1 (Miami R.)	Sediment Flood Dec. 75'	2292	6.3	15	146	25	7.4	.30		.14	.11	.05	32.3
M-Sed-2	Topsoil Below Sample 1	2293	5.9	14	128	24	6.4	.35		.15	5.3	.16	38.4
K-Sed-1 (Kilchis R.)	Sediment Flood Dec. 75'	2294	6.3	19	170	34	6.3	.33		.12	1.1	.04	36.8
K-Sed-2	Topsoil Below Sample 1	2295	6.0	12	164	25	5.9	.35		.17	6.8	.26	46.2
W-Sed-1 (Wilson R.)	Sediment Flood Dec. 75'	2296	6.4	16	112	32	6.9	.26		.26	1.2	.05	30.2
W-Sed-2	Topsoil Below Sample 1	2297	6.1	9	156	30	6.3	.37		.19	7.1	.19	42.6
T-Sed-1 (Trask R.)	Sediment Flood Dec. 75'	2298	6.6	9	106	38	7.3	.26		.13	.44	.01	31.5
T-Sed-2	Topsoil Below Sample 1	2299	6.3	16	156	30	6.4	.28		.30	2.0	.06	30.1

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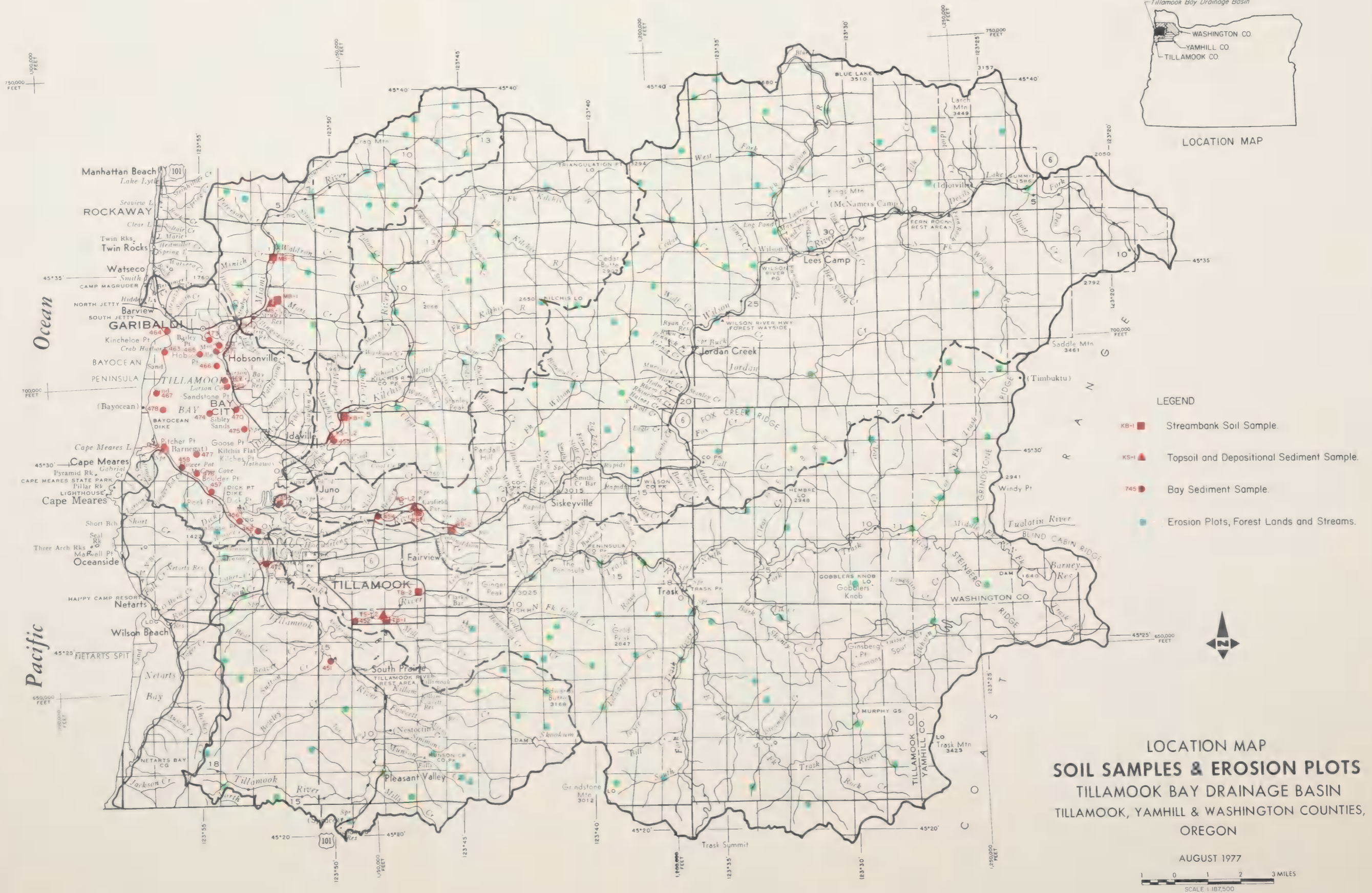
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Determination of channel reaches was based on bank heights as observed and measured in the field. Each reach of channel, as traced on drafting film from each of two aerial photo flights taken at different times, was cut out and the area determined by weight. Simultaneously, the area of streambank erosion and the average bank height were then used to obtain the volume of soil loss in acre feet and converted to tons for each reach of channel due to bank erosion which occurred during the period between the two flights.

To further substantiate the foregoing data, all of the channel within the agricultural lands in each of the five tributary drainages were checked in the field to verify conditions as established on the aerial photos. At that time, all necessary changes were made so as to update any erosion problems to the current year (1977).

Critically eroding sections of unprotected channel bank were located, studied and measured to determine a reasonable erosion rate and the number of surface acres lost by bank recession which had been and still appears to be occurring. (See Stream Stability Map) The remaining banks were placed in a non-critical category and an erosion rate under present conditions was estimated based on visual examination.

#### FOREST LANDS

Erosion sources on forest lands were inventoried using false color infrared aerial photographs taken from U-2 aircraft in 1975. A scale of 2 inches per mile was used. Ground truth data was obtained from a field survey to assure correct photo interpretation. The erosion sources were grouped into 29 categories as follows:

<u>Group</u>	<u>Subgroup</u>
Roads-----	Paved Gravel 2-lane Secondary 1½ lane Spurs 1-lane Skid roads ½-lane
Trails-----	Fire trails Rail grades used Rail grades abandoned Transmission lines Motorbike trails
Landslides-----	Upper 1/3 slope Middle 1/3 slope Lower 1/3 slope

Streams-----	Channel bank Channel bottoms Flood plain scour
Clearcuts-----	>75 percent bare ground 50-75 percent bare ground 25-50 percent bare ground <25 percent bare ground
Forested Areas-----	Brush and seedlings Saplings and poles Mature second growth Hardwoods Old growth
Burns-----	>75 percent bare ground 50-75 percent bare ground 25-50 percent bare ground <25 percent bare ground

The actual length for each corridor erosion source in miles and the mean erosion width were determined by field measurement.

Landslides were inventoried by slope position using false color infrared low elevation aerial photography flown in 1975. Erosion plots were used to determine the erosion rates. The erosion rates were so high on many plots as to completely erode the plot pins and troughs.

Stream stability was determined using the USFS Stream Reach Inventory and Channel Stability Evaluation System, USFS R-1, 1975. Correlations between stream stability and channel erosion were established using index transects along selected streams to arrive at coefficients for lateral migration, aggradation, and degradation. (See Stream Stability map following page VI-4)

The clearcut, forested and burn areas and the percent of bare ground were determined using satellite infrared imagery and the computer program called LANDSAT (PIXSYS) developed by the Earth Resources Remote Sensing Applications Laboratory (ERSAL) at Oregon State University, Corvallis, Oregon. The ground field survey, pixel signatures, and interpretations were done by the USFS.

The bedload component of gross sediment was determined by field measurement using a Helli Smith bedload sampler and correlation of the resulting data with actual bedload removal data from two channel gravel mining operations located in the Miami and Trask Rivers.

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Source:  
Base map furnished by Oregon State Staff.  
Thematic detail prepared by SCS, WTSC Cartographic Staff from data  
based on field survey using the U.S.F.S. Stream Reach Inventory and  
Stability Evaluation System-1975.  
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR, 1978

# **CRITICAL STREAMBANK ZONES AND STREAM STABILITY MAP TILLAMOOK BAY DRAINAGE BASIN TILLAMOOK, YAMHILL & WASHINGTON COUNTIES, OREGON**

NOVEMBER 1978

1 0 1 2 3 MILES  
SCALE 1: 187,500





Figure VI-1  
FOREST LAND  
by SUBBASIN



The sediment samples were field collected at 14 primary sediment-discharge sampling stations in the basin. (See Recording Gages and Sediment Sampling Stations Map following Page VI-6). Several secondary sampling stations were also established to get estimates of sediment delivery ratios within the subwatersheds. The computer program titled Polynominal Regression (RPOLY) is filed at the USDA Fort Collins, Colorado Computer Center. This is a USFS Region 6 program developed by the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Figures VI-2, VI-3, VI-4, and VI-5 are the sediment-discharge regression for the 14 primary fluvial sediment data collection stations. The ( $r^2$ ) coefficients of determination for these stations range from .66 to .99 and average .91. In most cases the quadratic or cubic expression resulted in the best data fit. One analytical value of these regression lines is that as restoration needs are implemented and erosion and resulting fluvial sediment is reduced, the slope of the new regression lines will become more vertical and the resulting water quality improvement can be measured.



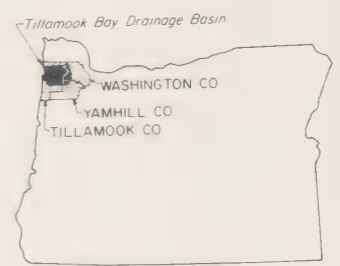
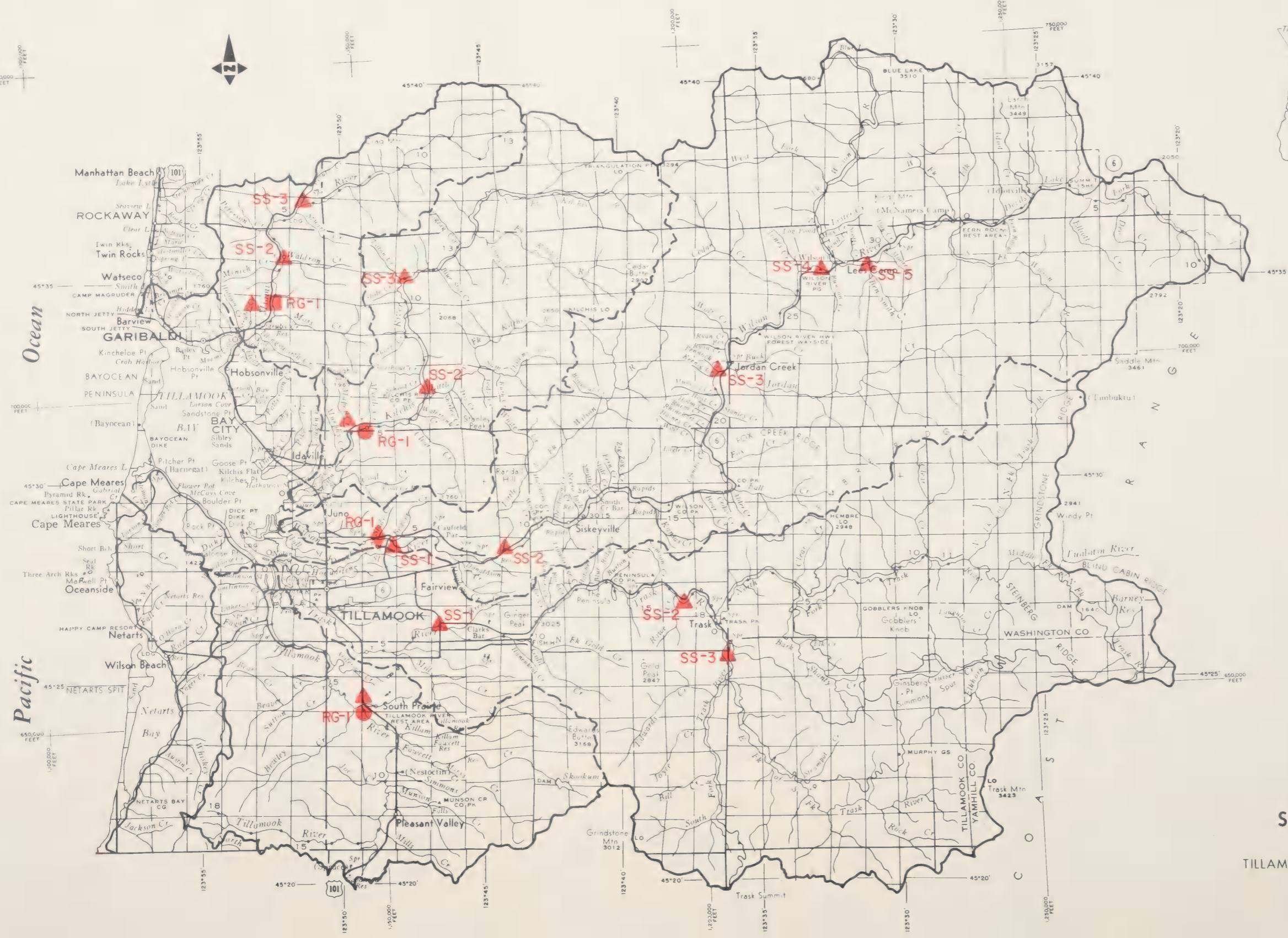
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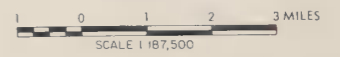


LOCATION MAP

LEGEND

- SCS Recording Gage
- Oregon State Recording Gage
- ◆ USGS Recording Gage
- ▲ Suspended Sediment Load Sampling Stations

RECORDING GAGES AND  
SEDIMENT SAMPLING STATIONS  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON  
APRIL 1977



Source:  
Base map furnished by Oregon State Staff.  
Thematic detail compiled by State Staff.  
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE WASH. FIELD OFFICE



Figure VI-2 Comparative Analysis of Sediment / Discharge - Miami River.

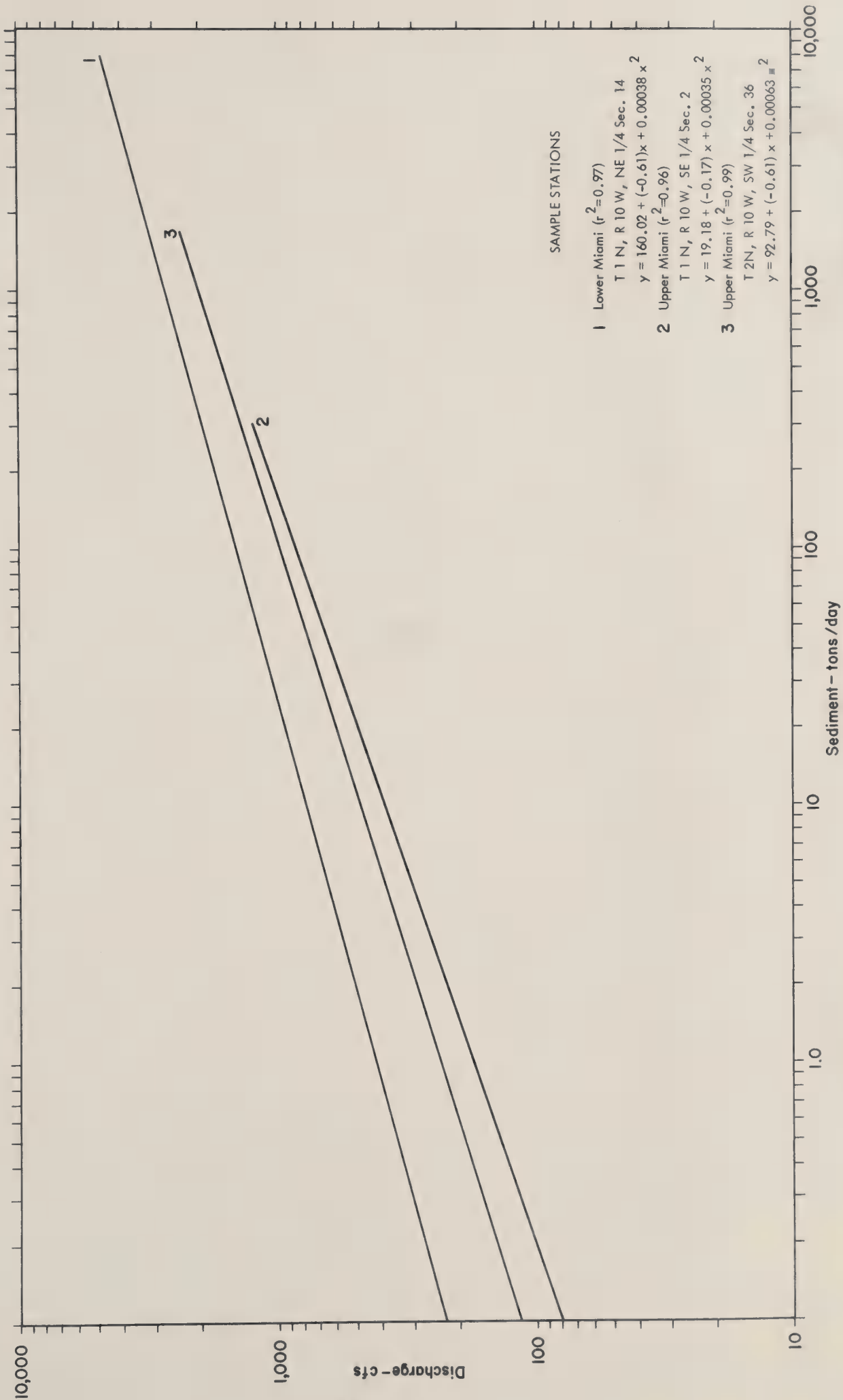


Figure VI-3 Comparative Analysis of Sediment / Discharge - Kilchis River.

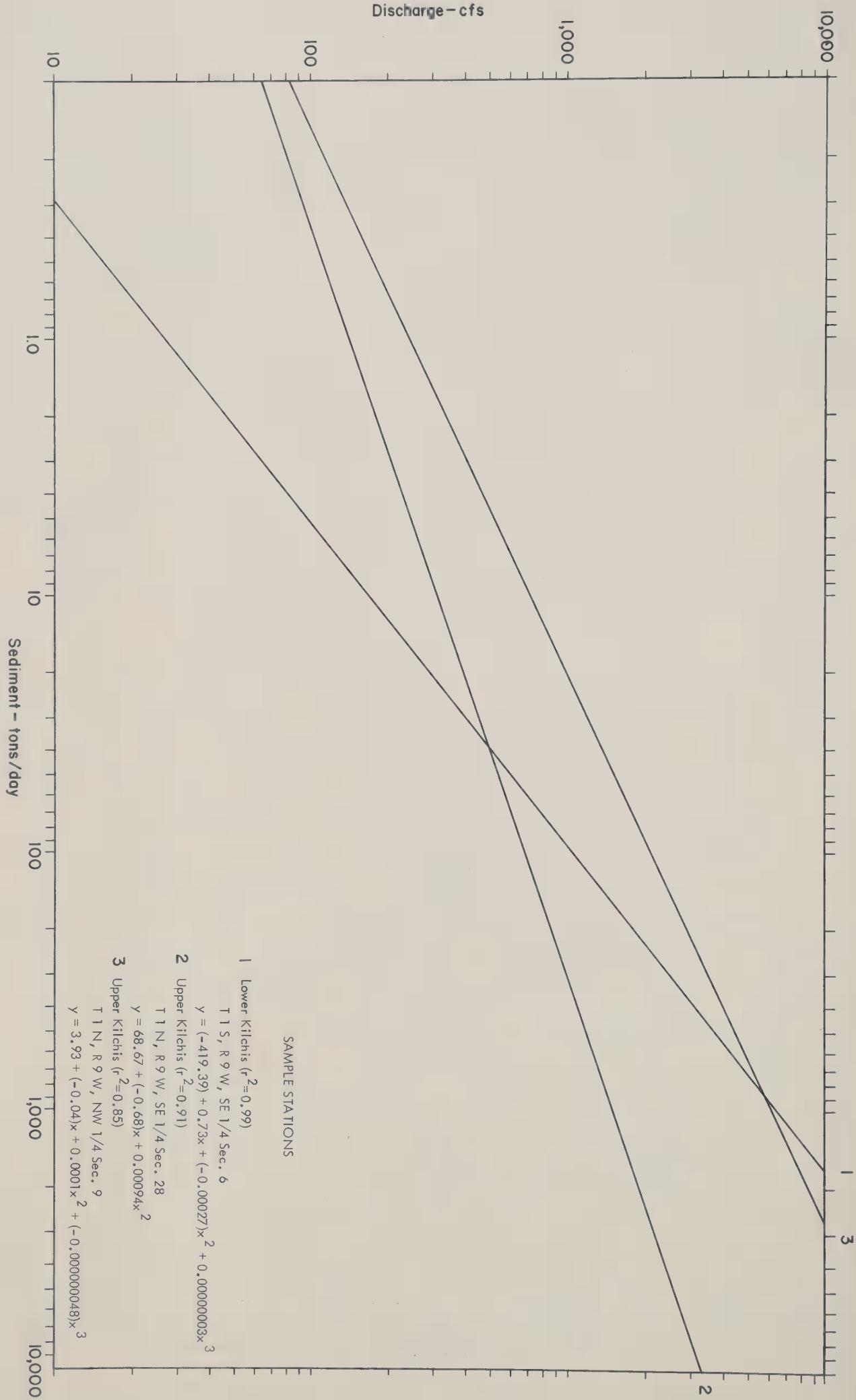


Figure VI-4 Comparative Analysis of Sediment / Discharge – Wilson River.

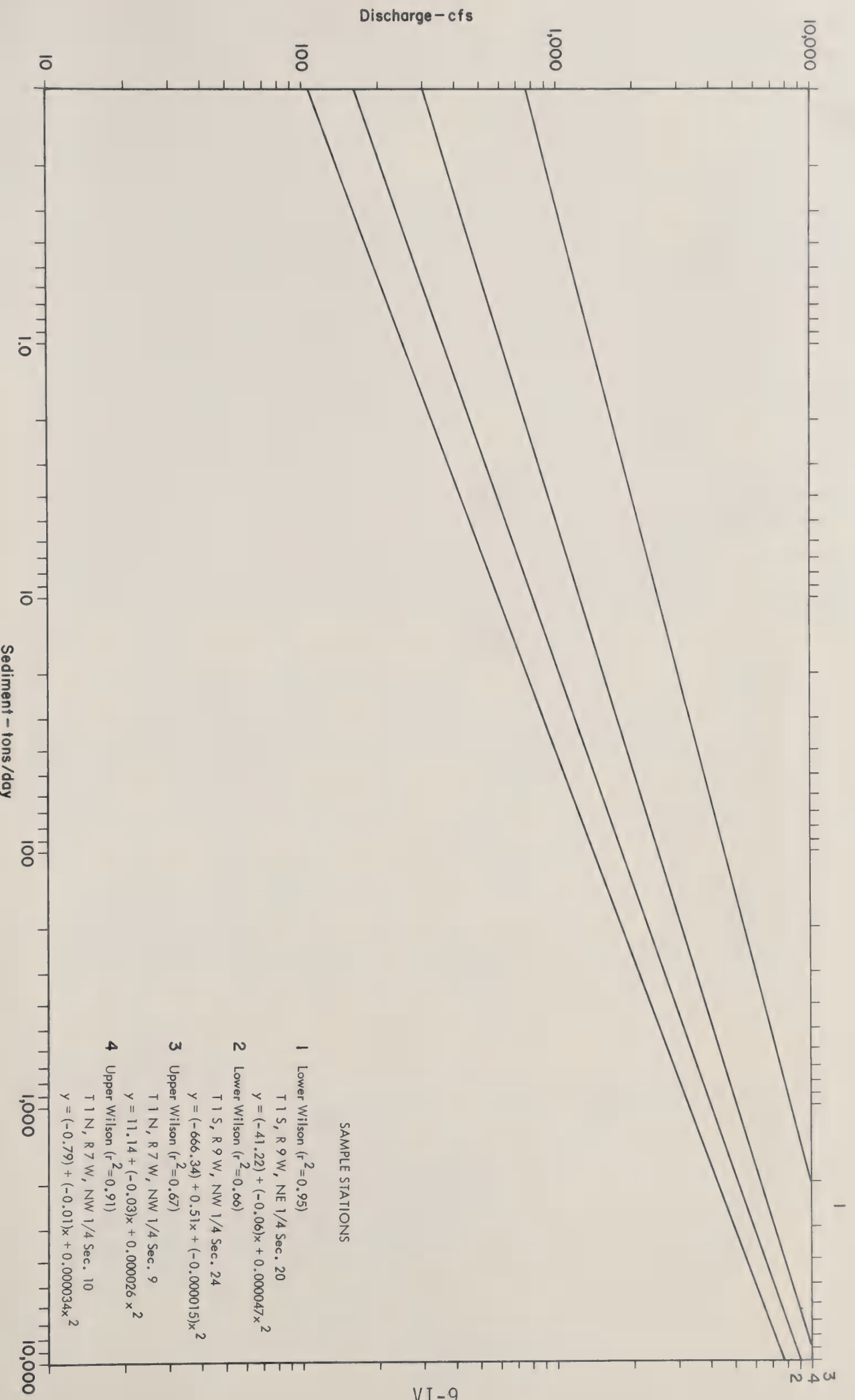
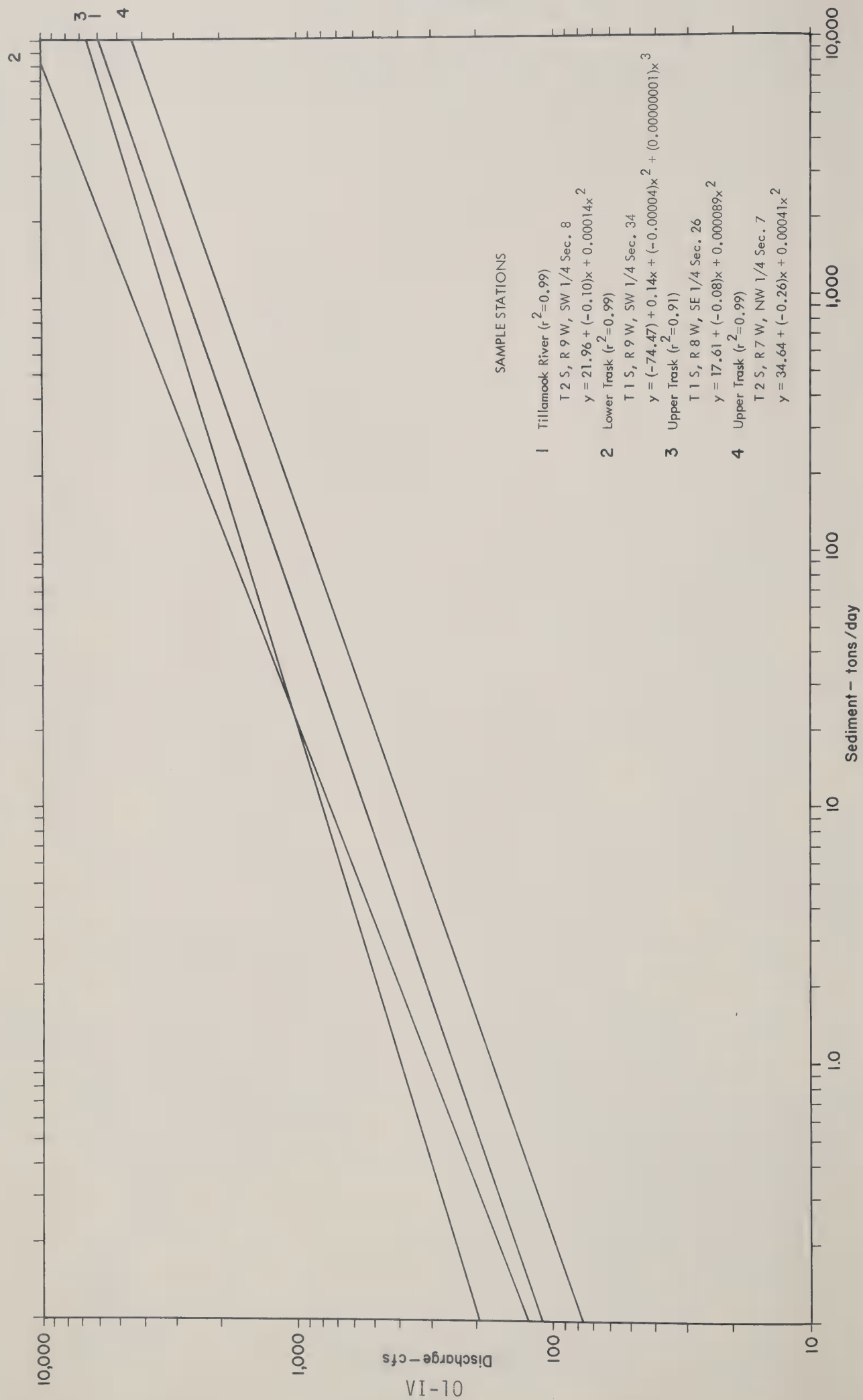


Figure VI-5 Comparative Analysis of Sediment/Discharge-Tillamook and Trask Rivers.



## TILLAMOOK BAY

Sediment samples were obtained at 52 surface sites and 17 core sites in and around Tillamook Bay (See map Figure 1, Sample Locations and Data). Surface sediment samples were collected by either a standard U.S. BM54 sampler or by hand dipping a 454 gram (g) sample container to a maximum depth of 2 inches below the sediment surface. Ten surface sediment samples were collected near or above the head of tides in the five major rivers entering Tillamook Bay Estuary and an additional 11 samples were obtained from the tidally effected portions of the major rivers. The remaining 31 samples are from intertidal to shallow subtidal environments within Tillamook Bay Estuary proper. For purposes of analyzing the data, the bay samples are assigned to one of four geographic parts for the bay. These parts are called: (1) South-western Margin, (2) Western Margin, (3) Central Bay, and (4) Eastern Margin. The western and central parts are divided into "bay" and "ocean" and "southern" and "northern" portions, respectively. In general, the margin parts probably extend bayward from the shoreline to about the nearest deep tidal channel, and the central part includes all of the bay isolated from the shoreline by a deep channel or channels.

Core samples were obtained by augering to the sample depth, removing the center plug from the hollow stem of the auger, inserting a split tube sampler about 18.4 inches long and 2.4 inches in diameter, and driving the tube into the sediments below the bottom of the auger. Core site locations include two on land adjacent to the estuary and 15 within Tillamook Bay proper. For purposes of comparing and analyzing core data, core sample sites also are assigned to the appropriate marginal or central geographic parts of the bay.

With the exception of two core sites, the bay locations are all in intertidal environments very close to mean lower low water (MLLW). The sediment surface, which is used as a datum for sample depths at all core sites, ranges from 1.9 feet in the upper part of the bay to 2.9 feet in the lower bay below the standard geodetic mean sea level (MSL) datum.

## Sample Analyses

To determine modern and Holocene sources of sediments in the Tillamook Bay Estuary, surface and core sediment samples were analyzed for quantitative and qualitative aspects of the components in the nonopaque heavy (specific gravity greater than 2.96) fraction of the very fine sand (between 62 and 125 micrometers) materials. Between 200 and 300 nonopaque grains were identified and counted by standard optical petrographic techniques in each surface sample and in 55 samples from the core sites.

To evaluate Holocene sediment deposition rates and depositional history, heavy mineral compositional data were combined with field and laboratory observations of stratigraphic variations in sediment colors, texture, organic content, and drilling characteristics. In addition, 13 core samples from various depths at five core sites were analyzed for their age by the radiocarbon technique.

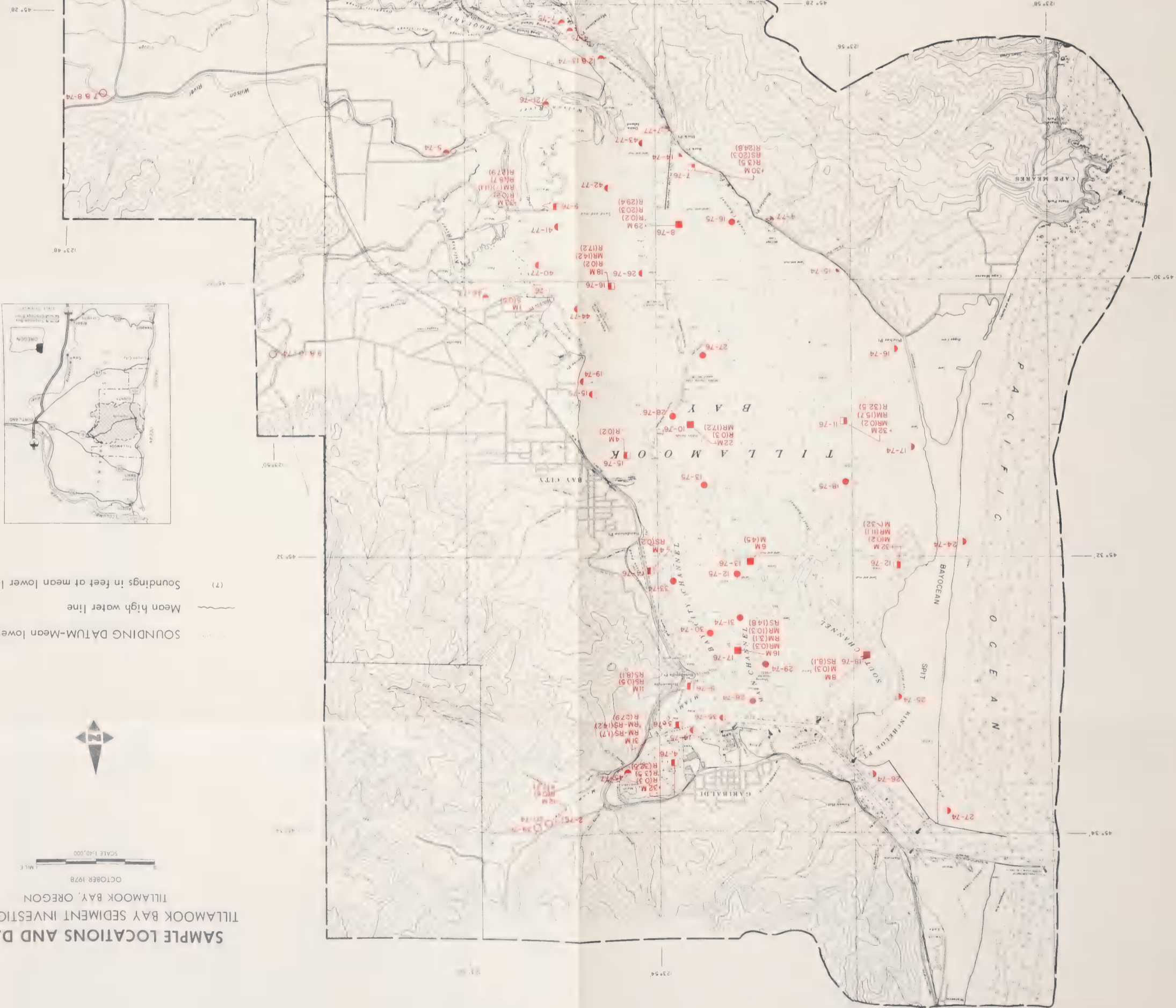
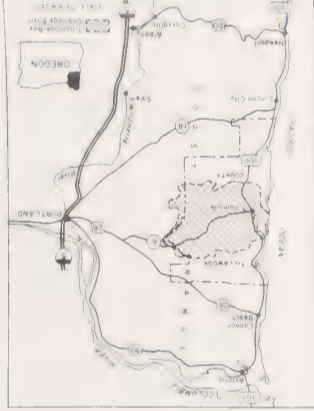
## Sample Locations and Data



## TILLAMOOK BAY SEDIMENT INVESTIGATION

OCTOBER 1978

(2)



### Surface Sediment Sample Sites

- Core Sample Sediment Sources
- River
  - ◐ Tidal River
  - ◑ Southwestern Margin
  - ◒ Western Margin
  - Central Bay
  - ◓ Eastern Margin
- Core Sediment Sample Sites
- Land
  - ◑ Southwestern Margin
  - ◒ Western Margin
  - Central Bay
  - ◓ Eastern Margin

Depth to the Base of the Modern Fill # Meters 29M



## CHAPTER VII

### EROSION & SEDIMENT PROBLEMS



# EROSION AND SEDIMENT PROBLEMS

## SEDIMENT AND DEBRIS DEPOSITION

### AGRICULTURAL LANDS

Sediment deposition on agricultural lands in the Tillamook basin occurs periodically from prolonged overbank flooding concurrent with sheet and rill erosion. It is estimated that there are 5,700 tons of sediment per year which occur as a result of sheet and rill erosion. Due to the suspended nature of the sediment, only 1,300 tons/year or approximately 25 percent is projected as reaching any one of the five major drainage channels. The remaining sediment is trapped in isolated areas due to obstructions, such as roads, railroads, farmsteads, and general areas of brush and timber.

Overbank flooding and crosscountry flow of varying velocities have resulted in deposition of coarse debris, logs, etc., over large areas of farmland. Complete removal is necessary to return the land to a normal level of productivity.

### FOREST LANDS

Forest lands and croplands have been separated in the study for inventory and analysis. The two areas are not independent, however; upstream problems can either amplify or reduce downstream problems. The total sediment in the system is the crucial problem. This is summarized in Table VII-1.

An estimate of the historic sediment trend from forest lands was made using recent data. This was accomplished by using current sediment data from stable subwatersheds composed primarily of old-growth timber to represent forest land watershed conditions in 1875. The fire occurrence map which shows fires by area, size, and year of occurrence was a basis for determining past land disturbance along with road intensity, timber harvest, salvage logging, and other land disturbance activities over time. Old existing cedar stumps were indicators for depth of soil loss. Stream flow data from the Wilson River USGS gage (1914-1975) and early precipitation data were also used. The following sediment graph from 1875 to 1975 is only an estimate (Figure VII-1). If the conditions portrayed on the graph are approximately representative, we can assume there has been a 20-fold increase in sediment from the forest lands today as compared with average conditions which existed in 1875. The gross sediment from forest lands today is only 12.5 percent of the extremely high rate which probably occurred between 1939 and 1945 as a result of wildfire and salvage logging.

Table VII-1, TOTAL EROSION AND SEDIMENT  
BY RESOURCE AREA (MEAN ANNUAL)

Resource Area	Acres	Gross Erosion (tons)	Gross Sediment (tons)
Forest Resource Area	323,050	286,245	51,603.0
Agricultural Resource Area	29,490	13,381	9,010.0
Bay Area	10,980	<u>1/</u>	<u>1/</u>
Total	363,520	299,626	60,613.0

1/ Erosion and sediment not determined in this study.

## SOIL EROSION

### AGRICULTURAL LANDS

Erosion on agricultural lands in the basin is confined to two types--sheet and rill erosion and streambank cutting. Although the vegetative cover is generally permanent pasture and in good condition, overbank flow during periods of high water has resulted in sporadic sheet and rill erosion. Erosion occurs in the form of very narrow rivulets which traverse the very gentle slopes prevailing in the flood plain area. Occasional small gullies occur in isolated areas but are considered to be an insignificant source to the overall erosion picture.

Streambank erosion along the five drainages in the basin is the more prevalent of the two types. Overbank flooding in periods of high water results in saturation of exposed bank areas and collapse of the soil profile as the water recedes. During moderately high flows, increased velocities result in undercutting and collapse of both exposed and vegetated streambanks, with the major problems generally occurring in the outer bank of the channel curves. Isolated sections of streambank along each drainage are affected by the movement of cattle from agricultural land into the channel bottom during periods of low water. This causes deterioration of the bank, resulting in additional contribution of sediment to the channel and the bay.

No serious degradation or aggradation is apparent in the channel bottoms. However, stream bottom scour causes constant shifting of the



Channel bank erosion--Agricultural land.



Riprap installation--Agricultural land.

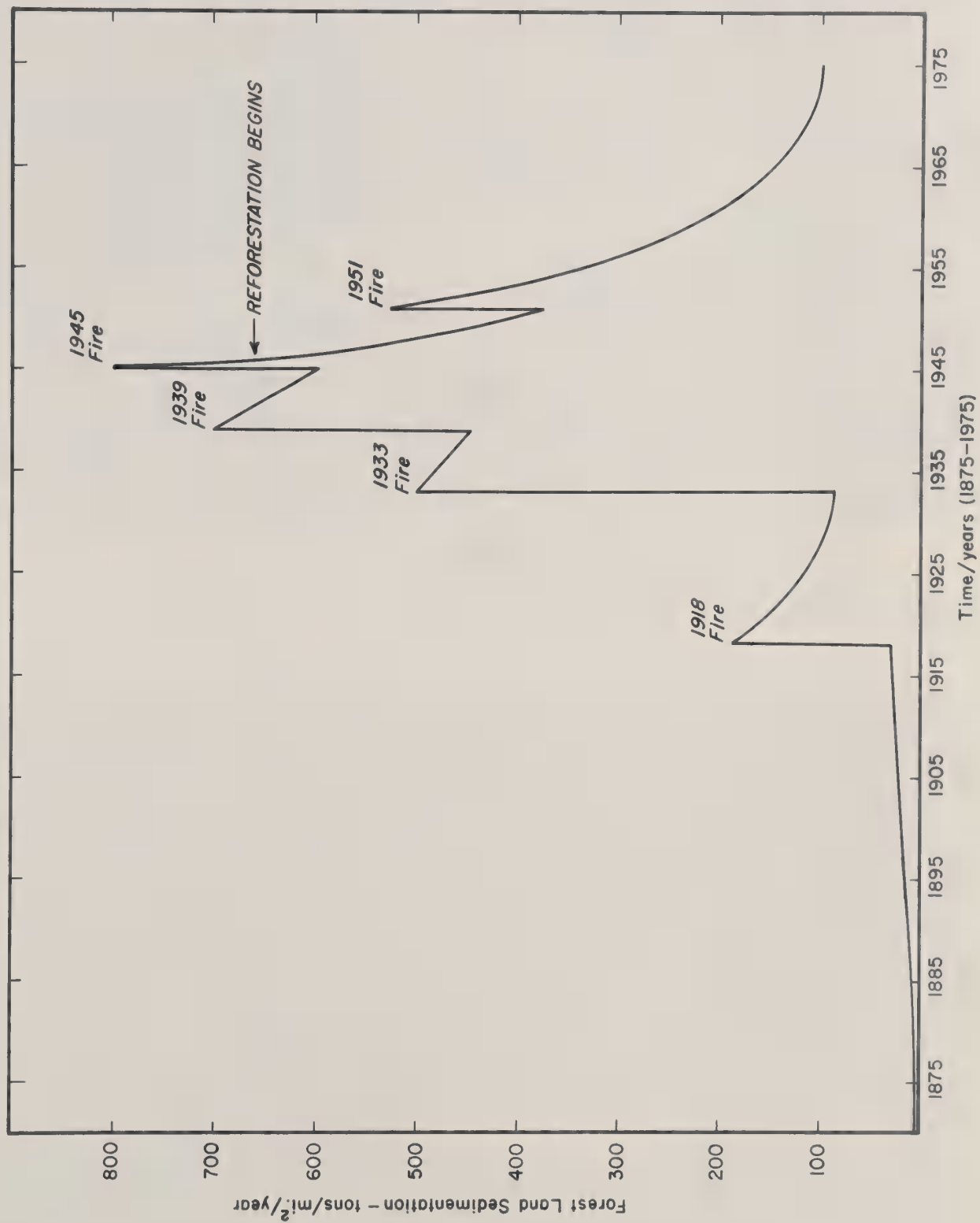


Overbank flooding on agricultural lands.



Sediment deposition on agricultural land.

Figure VII-1 Estimated Sediment Rates 1875-1975



channel gravel deposits resulting in erosive changes and moderately high soil losses, depending on the volume and velocity of streamflow. Commercial gravel operations within four of the rivers also cause periodic changes in channel flow and result in reduction in the amount of sediment available for transport.

Erosion data is displayed and summarized for agricultural lands by the five subbasins. A summary of this data is presented in Tables VII-2 thru VII-7.

## FOREST LANDS

Erosion of forest lands is physically important to the development of the flood plain and estuarine resources. Due to numerous fires and increasing activity by man on the upper basin slopes, erosion has occurred to such a degree that both corrective and protective measures had to be taken to reduce soil losses.

The five subbasins of the Tillamook basin forest resource area, each a complete river drainage, were further divided into 11 subbasins to facilitate studies on forest lands (see Figure VI-1).

Erosion rates and sediment sources were inventoried and measured in the field and by false-color infrared aerial photography. The basis for erosion estimates was erosion plots utilizing troughs and pins. The fluvial sediment estimates are based on a total of 404 sets of streamflow-gross fluvial sediment measurements. The regressions between streamflow and sediment have coefficients of determination ( $r^2$ ) ranging from .66 to .99. These regressions were applied to 10-year mean annual hydrographs based on the U.S. Geologic Survey long-term stream gaging station on the Wilson River and the runoff elevation regression.

Erosion and sediment data is displayed and summarized for forest lands by 11 subbasins. A summary of this data is presented in Table VII-8 thru VII-18. Mean annual gross erosion and fluvial sediment rates are depicted for the forest lands of the basin on the Mean Annual Gross Erosion and Sediment Rate map.

## EROSION AND SEDIMENT SUBBASIN SUMMARIES

### AGRICULTURAL LANDS - FIVE SUBBASINS

#### Miami Subbasin

The Miami Subbasin contains 1,260 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 220.2 tons from 1205.6 acres. Of this total, approximately 27 percent or 59.0 tons of sediment per year reaches the Miami River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.



Two tributaries to the Wilson River which received large amounts of deposition.





Deposition of fine sediments on the Lower Wilson. Note debris on upper banks and in branches of the brush.



The fine sediments on this Lower Wilson terrace were left by the November 1977 high flows. This is part of a long-term natural process which creates valley agricultural lands.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 10.9 acres is 1211.2 tons. Of this total, approximately 92 percent or 1114.3 tons per year is transported to the bay area. A total of 774 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-3). The mean annual gross erosion on these critical unprotected banks is 134 tons, of which 92 percent or 123 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.75 to 1.2 feet per year. In the non-critical area, a total bank length of 39,362 lineal feet was examined and estimated to have an annual loss of 372 tons under existing conditions.

#### Kilchis Subbasin

The Kilchis subbasin contains 3,600 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 534 tons from 3350.1 acres. Of this total, approximately 25 percent or 126.8 tons of sediment per year reaches the Kilchis River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by manmade obstacles and deposited on farmland.

The mean annual gross erosion caused by streambottom scour and channel bank cutting on 18.6 acres is 1413.6 tons. Of this total, approximately 92 percent or 1300.5 tons per year is transported to the bay area. A total of 1,133 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-4). The mean annual gross erosion on these critical unprotected banks is 262 tons of which 92 percent or 241 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.50 to 1.1 feet. In the non-critical area, a total bank length of 40,330 lineal feet was examined and estimated to have an annual loss of 416 tons under existing conditions.

#### Wilson Subbasin

The Wilson subbasin contains 4,430 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 634 tons from 4090.3 acres. Of this total, approximately 23 percent or 144 tons of sediment per year reaches the Wilson River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 33.5 acres is 1,973 tons. Of this total, approximately 95 percent or 1,874.3 tons per year is transported to the bay area. A total of 1,136 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-5). The mean annual gross erosion on these critical unprotected banks is 229 tons, of which 95 percent or 217.5 tons is assumed to reach the bay area. The average annual bank recession rate ranged from 0.58 to 1.0 feet. In the non-critical area, a total bank length of 70,041 lineal feet was examined and estimated to have an annual loss of 520 tons under existing conditions.

### Trask Subbasin

The Trask subbasin contains 11,090 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 1896.4 tons from 10,651.7 acres. Of this total, approximately 21 percent or 397 tons of sediment per year reaches the Trask River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 44.8 acres is 2,479 tons. Of this total, approximately 95 percent or 2355 tons per year is transported to the bay area. A total of 1,666 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-6). The mean annual gross erosion on these critically unprotected banks is 435 tons, of which 95 percent or 413.2 tons is assumed to reach the bay area. The average annual bank recession rate ranged from 0.50 to 0.80 feet. In the non-critical area, a total bank length of 88,304 lineal feet was examined and estimated to have an annual loss of 591 tons under existing conditions.

### Tillamook Subbasin

The Tillamook subbasin contains 9,570 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 1,868 tons from 9,340 acres. Of this total, approximately 20 percent or 370 tons of sediment per year reaches the Tillamook River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by manmade obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 34.7 acres is 1,151.7 tons. Of this total, approximately 93 percent or 1,071 tons per year is transported to the bay area. A total of 766 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-7). The mean annual gross erosion on these critical unprotected banks is 162 tons, of which 93 percent or 150.6 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.30 to 0.75 feet. In the non-critical area, a total bank length of 162,533 lineal feet was examined and estimated to have an annual loss of 105 tons per year under existing conditions.

Table VII-2, EROSION AND SEDIMENT INTENSITY BY SUBBASINS <sup>1/</sup>  
 (Agricultural Lands - Based on Unit Production)

Subbasin	Erosion Load Rank	Sediment Load Rank
Miami	1	1
Kilchis	2	3
Wilson	3	4
Trask	5	5
Tillamook	4	2

<sup>1/</sup> Lowest Contributor (1)  
 Highest Contributor (5)

TABLE VII-3

MIAMI RIVER  
PRESENT EROSION ON STREAMBANKS  
AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS <sup>1/</sup> <sup>3/</sup>				AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	NON-CRITICAL EROSION AREAS <sup>1/</sup> <sup>3/</sup>		
		SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)		EST. EROSION <sup>4/</sup> RATE (Cu.Ft./Lin.Ft.Yr.)	(Cu.Ft./Yr.)	EROSION T/Yr. AF/Yr.)
1	-	-	-	-	-	-	3,590	0.1 <sup>2/</sup>	359	14 .008
2	-	-	-	-	-	-	4,165	0.2	833	33 .019
3	-	-	-	-	-	-	2,103	0.35	736	29 .01
4	-	-	-	-	-	-	2,500	0.2	500	20 .01
5	7' vertical	.037	233	7	49	1,324	2,478	0.3	743	30 .01
6	-	-	-	-	-	-	3,850	0.35	1,347	54 .03
7	4' vertical	.024	262	4	31	1,292	14,905	0.2	2,891	116 .066
8	-	-	-	-	-	-	2,475	0.3	743	30 .017
9	4' vertical	.026	279	4	54	2,077	3,296	0.35	1,154	46 .026
		<u>0.087</u>	<u>774</u>		<u>134</u>	<u>4,693</u>	<u>39,362</u>		<u>9,306</u>	<u>372</u> 0.19

<sup>1/</sup> Erosion on banks not riprapped.

<sup>2/</sup> Channel bank recession affected by tidal action.

<sup>3/</sup> Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

<sup>4/</sup> These are field estimates based on judgment and experience of the geologist.

NOTE: 13,697 lin. ft. or 2.0 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII-4

KILCHES RIVER  
PRESENT EROSION ON STREAMBANKS  
AGRICULTURAL LAND

CRITICAL EROSION AREAS <u>1/</u> <u>3/</u>							NON-CRITICAL EROSION AREAS <u>1/</u> <u>3/</u>					
REACH	CHANNEL BANK (CRITICAL EROSION)	SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION <u>4/</u> RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	T/Yr.	AF/Yr.
1	-	-	-	-	-	-	-	3,700	0.2 <u>2/</u>	740	30	.016
2	-	-	-	-	-	-	-	3,328	0.24	799	32	.018
3	7' angular	.033	206	7	43	1,303	0.75	894	0.1	894	4	.002
4	-	-	-	-	-	-	-	1,925	0.1	193	8	.004
5a	8' vertical	.034	187	8	45	1,324	0.75	6,137	0.3	1,841	74	.042
5b	7' vertical	.044	276	7	77	1,750	1.0					
6	-	-	-	-	-	-	-	2,810	0.2	562	22	.012
7	8' vertical	.044	243	8	39	886	0.50	2,507	0.3	752	30	.017
8	6' vertical	.030	221	6	58	1,933	1.1	6,654	0.25	1,664	67	.038
9	-	-	-	-	-	-	-	12,375	0.3	3,713	149	.085
								40,330		10,353	416	0.234

<sup>1/</sup> Erosion on banks not riprapped.

<sup>2/</sup> Channel bank recession affected by tidal action.

<sup>3/</sup> Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

<sup>4/</sup> These are field estimates based on judgment and experience of the geologist.

NOTE: 40,330 lin. ft. or 3.2 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII-5

WILSON RIVER  
PRESENT EROSION ON STREAMBANKS  
AGRICULTURAL LAND

CRITICAL EROSION AREAS 1/ 3/										NON-CRITICAL EROSION AREAS 1/ 3/			
REACH	CHANNEL BANK (CRITICAL EROSION)	SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION 4/ RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION			
										(Cu.Ft./Yr.)	(Cu.Ft./Yr. T/Yr.)	AF/Yr.)	
1	-	-	-	-	-	-	-	8,777	0.2 2/	1,755	70	.04	
2	15' vertical	.078	229	15	80	1,026	0.582	30,571	0.1	3,057	122	.07	
3	-	-	-	-	-	-	-	6,050	0.24	1,452	58	.03	
4	-	-	-	-	-	-	-	1,650	0.1	165	6.6	.004	
5	8' vertical	.034	185	8	30	882	0.50	8,065	0.26	2,097	84	.048	
6a	5' vertical	.057	500	5	75	1,316	0.75	14,928	0.3	4,478	179	.10	
6b	5' angular	.025	222	5	44	1,760	1.0						
								70,041		13,004	520	0.29	

<sup>1/</sup> Erosion on banks not now riprapped.

<sup>2/</sup> Channel bank recession affected by tidal action.

<sup>3/</sup> Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

<sup>4/</sup> These are field estimates based on judgment and experience of the geologist.

NOTE: 23,863 lin. ft. or 8.8 acres of banks protected by riprap not included in above figures. These areas are classes as non-critical and do not require any additional treatment measures.

TABLE VII-6

TRASK RIVER  
PRESENT EROSION ON STREAMBANKS  
AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS <u>1/</u> <u>3/</u>				AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	NON-CRITICAL EROSION AREAS <u>1/</u> <u>3/</u>		
		SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)			EST. EROSION <u>4/</u> RATE (Cu.Ft./Lin.Ft.Yr.)	(Cu.Ft./Yr.)	EROSION T/Yr. AF/Yr.)
1	-	-	-	-	-	-	17,487	0.2 <u>2/</u>	3,497	140 .080
2a	10' vertical	.055	243	10	49	0.50	) 21,030 )	0.1	2,103	84 .048
2b	10' angular	.045	199	10	48	0.60				
2c	10' angular	.058	253	10	51	0.50				
3	15' angular	.106	308	15	96	0.52	16,342	0.2	3,268	131 .075
4	10' vertical	.090	396	10	127	0.80	11,154	0.1	1,115	45 .025
5	12' vertical	.073	267	12	64	0.50	8,183	0.3	2,455	98 .056
6	-	-	-	-	-	-	4,623	0.2	925	37 .021
7	-	-	-	-	-	-	3,575	0.1	358	14 .008
8	-	-	-	-	-	-	4,675	0.2	935	37 .021
9	-	-	-	-	-	-	1,235	0.1	124	5 .002
		4.27	1,666		435		88,304		14,780	591 0.336

1/ Erosion on banks not riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 21,318 lin. ft. or 8.68 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII- 7

TILLAMOOK RIVER  
PRESENT EROSION ON STREAMBANKS  
AGRICULTURAL LAND

CRITICAL EROSION AREAS 1/ 3/										NON-CRITICAL EROSION AREAS 1/ 3/			
REACH	CHANNEL BANK (CRITICAL EROSION)	SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION 4/ RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr. T/Yr.	AF/Yr.		
1	-	-	-	-	-	-	-	18,700	0.02 2/	374	15	.008	
2	-	-	-	-	-	-	-	29,700	0.02	594	24	.013	
3	-	-	-	-	-	-	-	8,800	0.01	88	4	.002	
4a	7' angular	.030	187	7	21	700	0.40	}	0.01	264	10	.006	
4b	7' angular	.029	183	7	15	577	0.30						
5	12' vertical	.059	215	12	77	1,305	0.75	21,385	0.02	428	17	.009	
6	7' vertical	.029	181	7	25	862	0.50	29,229	0.02	585	23	.013	
7	-	-	-	-	-	-	-	28,600	0.01	286	12	.006	
								162,533		2,619	105	0.057	

<sup>1/</sup> Erosion on banks not riprapped.

<sup>2/</sup> Channel bank recession affected by tidal action.

<sup>3/</sup> Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

<sup>4/</sup> These are field estimates based on judgment and experience of the geologist.

NOTE: 2,839 lin. ft. or 0.50 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

## FOREST LANDS

### Miami Subbasin

The Miami subbasin contains 24,290 acres of forested lands. A total of 96 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 20,492.0 tons or 540.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 2,041.4 tons or 53.7 tons per square mile. Of this gross sediment, approximately 47 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 10 percent; i.e., 10 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment. (See Mean Annual Gross Erosion and Sediment Rates

There are approximately 336 miles of road in the subbasin which amounts to 8.9 miles of road corridor per square mile. The area contains 610 visible landslides or 16.1 slides per square mile.

There are 1.2 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 196,263 acre feet or 8 feet in depth per acre.

### Upper Kilchis Subbasin

The Upper Kilchis subbasin contains 21,400 acres of forested lands. A total of 27 sets of flow/sediment data were collected in the subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.85. The mean annual gross erosion from this area amounts to 12,040.0 tons or 360.05 tons per square mile. The mean annual gross fluvial sediment from the forest lands amounts to 1,070.0 tons or 32.0 tons per square mile. Of this gross sediment, approximately 47 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 8.8 percent; i.e., 8.8 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 363 miles of road in this subbasin which amounts to 10.8 miles of road corridor per square mile. The area contains 515 visible landslides or 15.4 slides per square mile.

There are 1.3 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 178,262 acre feet.

### Lower Kilchis Subbasin

The lower Kilchis subbasin contains 15,010 acres of forested lands. A total of 38 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.95. The mean annual gross erosion from this area amounts to 11,704.7 tons or 578.5 tons per square mile. The mean annual gross fluvial sediment, from the forested lands amounts to 2,310.7 tons per year or 98.5 tons per square mile. Of this gross sediment, approximately 64 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 19.7 percent; i.e., 19.7 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 245 miles of road in this subbasin which amounts to 10.5 miles of road corridor per square mile. The area contains 210 visible landslides or 8.9 slides per square mile.

There are 1.1 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 112,575 acre feet or 7.5 feet in depth per acre.

### South Fork Kilchis Subbasin

The South Fork Kilchis subbasin contains 6,910 acres of forested lands. A total of 31 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 10,466.1 tons or 967.2 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 1,000.1 tons or 92.6 tons per square mile. Of this gross sediment, approximately 17 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 9.5 percent; i.e., 9.5 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 84 miles of road in this subbasin which amounts to 7.8 miles of road corridor per square mile. The area contains 131 visible landslides or 12.1 slides per square mile.

There are 1.9 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 54,727 acre feet or 7.9 feet in depth per acre.

### Lower Wilson Subbasin

The Lower Wilson subbasin contains 47,720 acres of forested lands. A total of 26 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.95. The mean annual gross erosion from this area amounts to 41,535.4 tons or 557.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts

to 8,514.8 tons or 114.2 tons per square mile. Of this gross sediment, approximately 66 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 20.5 percent; i.e., 20.5 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 800 miles of road in this subbasin which amounts to 10.7 miles of road corridor per square mile. The area contains 689 visible landslides or 9.2 slides per square mile.

There are 0.8 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 397,507 acre feet or 8.3 feet in depth per acre.

#### Upper Wilson Subbasin

The Upper Wilson subbasin contains 56,960 acres of forested lands. A total of 51 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.81. The mean annual gross erosion from this area amounts to 28,833.3 tons or 324.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 4,325.4 tons or 46.8 tons per square mile. Of this gross sediment, approximately 41 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 15 percent; i.e., 15 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 1,323 miles of road in this subbasin which amounts to 14.9 miles of road corridor per square mile. The area contains 1,176 visible landslides or 13.2 slides per square mile.

There are 0.46 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 493,843 acre feet or 8.67 feet in depth per acre.

#### North Fork Wilson Subbasin

The North Fork Wilson subbasin contains 16,430 acres of forested lands. A total of 30 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.74. The mean annual gross erosion from this area amounts to 7,103.44 tons or 276.72 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 416.1 tons or 16.2 tons per square mile. Of this gross sediment, approximately 23 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 5.8 percent; i.e., 5.8 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 139 miles of road in this subbasin which amounts to 5.4 miles of road corridor per square mile. The area contains 91 visible landslides or 3.5 slides per square mile.

There are 0.66 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 131,440 acre feet or 8.0 feet in depth per acre.

#### Main Trask Subbasin

The main Trask subbasin contains 69,920 acres of forested lands. A total of 32 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.98. The mean annual gross erosion from this area amounts to 78,504 tons or 718.6 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 16,485.8 tons or 150.9 tons per square mile. Of this gross sediment, approximately 19 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 21 percent; i.e., 21 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 1,599 miles of road in this subbasin which amounts to 14.6 miles of road corridor per square mile. The area contains 453 visible landslides or 4.2 slides per square mile.

There are 0.69 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 541,880 acre feet or 7.75 feet in depth per acre.

#### East Fork Trask Subbasin

The East Fork Trask subbasin contains 18,830 acres of forested lands. A total of 26 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.91. The mean annual gross erosion from this area amounts to 29,002 tons or 985.8 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 7,250.5 tons or 246.5 tons per square mile. Of this gross sediment, approximately 11 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 25 percent; i.e., 25 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 370 miles of road in this subbasin which amounts to 12.6 miles of road corridor per square mile. The area contains 196 visible landslides or 6.6 slides per square mile.

There are 1.0 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 156,854 acre-feet or 8.3 feet in depth per acre.

#### South Fork Trask Subbasin

The South Fork Trask subbasin contains 13,190 acres or 20.61 square miles of forested land. A total of 16 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was .99. The mean annual gross erosion from this area amounts to 4,955.7 tons or 240.45 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 1,090.27 tons or 52.9 tons per square mile. Of this gross sediment, approximately 48 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 22 percent; i.e., 22 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 199 miles of road in this subbasin which amounts to 9.6 miles of road corridor per square mile. The area contains 473 visible landslides or 23.0 slides per square mile.

There are 1.21 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 113,170 acre feet or 8.6 feet in depth per acre.

#### Tillamook Subbasin

The Tillamook subbasin contains 33,570 acres of forested lands. A total of 31 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 41,628.7 tons or 793.7 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 7,097.6 tons or 135.3 tons per square mile. Of this gross sediment, approximately 7.6 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 17 percent; i.e., 17 percent of all erosion in the basin ends up as fluvial sediment.

There are approximately 630 miles of road in this subbasin which amounts to almost 12 miles of road corridor per square mile. The area contains 136 visible landslides or 2.6 slides per square mile.

There are 1.33 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 251,775 acre feet or 7.5 feet in depth per acre.

TABLE VII-8  
MIAMI RIVER  
EROSION AND SEDIMENT  
FOREST LANDS

	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>							
Paved Roads	6	30	22.0	1.15	25.30	.12	3.0
Gravel 2 Track	190	55	1,266.0	.45	569.70	.10	57.0
Secondary 1½ Track	80	60	582.0	1.38	803.16	.09	72.3
Spurs 1 Track	25	40	121.0	2.84	343.64	.08	27.5
Skid Rds. ½ Track	35	15	64.0	3.90	249.60	.09	22.5
			<u>2,055.0</u>		<u>1,991.40</u>		<u>182.3</u>
<b>TRAILS</b>							
Fire Trails	11	5	7.0	1.10	7.70	.05	.4
Rail Grades Used							
Rail Grades Abandoned							
Transmission Lines							
Motorbike Trails	3	3	<u>1.0</u>	3.18	<u>3.18</u>	.07	<u>.2</u>
			<u>8.0</u>		<u>10.88</u>		<u>.6</u>
<b>LANDSLIDES</b>							
Upper 1/3 Slope			371.0	2.86	1,061.06	.06	63.6
Middle 1/3 Slope			247.0	3.59	886.73	.12	106.4
Lower 1/3 Slope			<u>123.0</u>	4.35	<u>535.05</u>	.25	<u>133.7</u>
			<u>741.0</u>		<u>2,482.84</u>		<u>303.7</u>
<b>STREAMS</b>							
Channel Bank	9	5	5.5	250.80	1,379.40	.28	386.1
Channel Bottoms	5	15	9.0	170.60	1,535.40	.20	307.0
Flood Plain Scour	2	20	<u>5.0</u>	22.40	<u>112.00</u>	.60	<u>67.2</u>
			<u>19.5</u>		<u>3,026.80</u>		<u>760.3</u>
<b>CLEARCUTS</b>							
>75% Bare Ground			324.5	14.14	4,588.80	.08	367.1
50-75% Bare Ground			620.0	3.80	2,356.00	.07	164.9
25-50% Bare Ground			1,790.0	1.90	3,401.00	.06	204.0
<25% Bare Ground			<u>1,120.0</u>	.08	<u>89.60</u>	.05	<u>4.5</u>
			<u>3,854.5</u>		<u>10,435.40</u>		<u>740.5</u>
<b>FORESTED AREAS</b>							
Brush & Seedlings			1,990.0	.20	398.00	.04	15.9
Saplings & Poles			6,660.0	.05	333.00	.02	6.6
Mature 2nd-Growth			3,040.0	.03	91.20	.026	2.7
Hardwoods			3,970.0	.02	79.40	.0009	.7
Old-Growth			<u>1,300.0</u>	.01	<u>13.00</u>	.005	<u>.07</u>
			<u>16,960.0</u>		<u>914.60</u>		<u>25.97</u>
<b>BURNS</b>							
>75% Bare Ground			20.0	10.00	200.00	.04	8.00
50-75% Bare Ground			10.0	6.00	60.00	.03	1.80
25-50% Bare Ground			150.0	3.00	450.00	.02	9.00
<25% Bare Ground			<u>460.0</u>	2.00	<u>920.00</u>	.01	<u>9.20</u>
			<u>640.0</u>		<u>1,630.00</u>		<u>28.00</u>
<b>Water (Streams) 10' Wide</b>							
			12.0		.00	.00	
			<u>24,297.0</u>		<u>20,499.60</u>		<u>2,041.77</u>

Gross Acres = 24,297  
Gross Sq. Mi. = 37.95  
Total Miles Stream = 45  
Watershed: Road Ratio:  
8.84 Mi/mi<sup>2</sup>  
Total Miles of Road = 336

Gross Sediment = 2,041.77 Tons/yr.  
Gross Erosion = 20,499 Tons/yr.  
Gross Erosion = 539.97 Tons/mi<sup>2</sup>

Gross Sediment = 53.7 Ton/mi<sup>2</sup>yr.  
Suspended Sediment = 28.7 T/mi<sup>2</sup>yr.  
Bedload = 25 Tons/mi<sup>2</sup>yr.  
Sediment Delivery Rate = 10%

TABLE VII-9  
KILCHIS RIVER - LOWER MAIN STEM  
EROSION AND SEDIMENT  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>								
Paved Roads		2	35	8	1.20	9.6	.06	.58
Gravel 2 Track		110	40	533	.83	442.4	.10	44.24
Secondary 1½ Track		77	50	466	2.27	1,057.8	.09	95.20
Spurs 1 Track		28	25	84	4.15	348.6	.07	26.40
Skid Rds. ½ Track		28	12	40	5.85	234.0	.02	4.68
				<u>1,131</u>		<u>2,092.4</u>		<u>171.10</u>
<b>TRAILS</b>								
Fire Trails		4	15	7	.75	5.3	.05	.27
Rail Grades Abandoned		5	10	6	.20	1.2	.02	.02
Power Lines		5	40	24	.35	8.4	.08	.67
Motorbike Trails		2	4	1	6.25	6.2	.02	.12
				<u>38</u>		<u>21.1</u>		<u>1.08</u>
<b>LANDSLIDES</b>								
Upper 1/3 Slope				198	2.15	425.7	.20	85.14
Middle 1/3 Slope				66	2.80	184.8	.43	79.46
Lower 1/3 Slope				51	3.95	201.4	.65	130.91
				<u>315</u>		<u>811.9</u>		<u>295.51</u>
<b>STREAMS</b>								
Channel Bank				5	120.00	600.0	.85	510.00
Channel Bottoms				8	63.00	504.0	.95	479.00
Flood Plain Scour				3	10.50	31.5	.55	17.00
				<u>16</u>		<u>1,135.5</u>		<u>1,006.00</u>
<b>CLEARCUTS</b>								
>75% Bare Ground				150	10.90	1,625.0	.12	196.20
50-75% Bare Ground				180	8.40	1,512.0	.15	220.00
25-50% Bare Ground				450	4.60	2,070.0	.10	207.00
<25% Bare Ground				420	3.30	1,386.0	.05	69.30
				<u>1,200</u>		<u>6,593.0</u>		<u>692.50</u>
<b>FORESTED AREAS</b>								
Rock				10				
Brush & Seedlings				740	.19	140.6	.12	16.87
Saplings & Poles				4,870	.06	292.2	.08	23.38
2nd-Growth				3,690	.03	110.7	.09	9.96
Hardwoods				2,800	.02	56.0	.11	6.16
Old-Growth				130	.01	1.3	.10	.13
Water (Streams >10' Wide)				20				
				<u>12,260</u>		<u>600.8</u>		<u>56.50</u>
<b>BURNS</b>								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				50	8.80	440.0	.20	88.00
<25% Bare Ground								
<b>Total Forest Land Acres</b>				<u>15,010</u>		<u>11,694.7</u>		<u>2,310.60</u>

Gross Acre Forest Land = 15,010.0  
Gross Sq. mi. = 23.45  
Total Miles Perennial Stream =  
22 = 1.07/mi./mi<sup>2</sup>  
Total Miles Road = 245.0 - 10.45  
mi/mi<sup>2</sup>

Mean Annual Erosion = 11,694.7 Tn/Yr.  
Gross Erosion = 578.45 T/mi<sup>2</sup>  
Sediment Delivery Ratio = .197

Mean Annual Sediment = 2,310.60 Tn/Yr.  
Gross Sediment = 98.54 Tons/mi<sup>2</sup>/Yr.  
Suspended Sediment = 35.65 Tns/mi<sup>2</sup>/Yr.  
Bedload = 62.89 Tons/mi<sup>2</sup>/Yr.

TABLE VII-10  
KILCHIS RIVER - LITTLE SOUTH FORK  
EROSION AND SEDIMENT  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>								
Paved Roads								
Gravel 2 Track		20	30	73.00	1.50	109.5	.10	10.95
Secondary 1½ Track		30	30	109.00	2.40	261.6	.05	13.08
Spurs 1 Track		19	25	57.00	4.60	262.2	.10	25.74
Skid Rds. ½ Track		15	20	36.00	6.00	216.0	.10	21.60
				<u>275.00</u>		<u>849.3</u>		<u>71.37</u>
<b>TRAILS</b>								
Fire Trails								
Rail Grade Abandoned								
Power Lines								
Motorbike Trails		3	5	2.00	7.00	14.0	.12	1.68
<b>LANDSLIDES</b>								
Upper 1/3 Slope				91.00	3.00	273.0	.08	21.84
Middle 1/3 Slope				54.00	4.00	216.0	.09	19.44
Lower 1/3 Slope				51.00	7.00	357.0	.45	160.69
				<u>196.00</u>		<u>846.0</u>		<u>201.97</u>
<b>STREAMS</b>								
Channel Bank		2	3	.73	155.00	113.1	.97	109.17
Channel Bottoms		1	10	1.27	80.00	101.6	.50	50.80
Flood Plain Scour								
				<u>2.00</u>		<u>214.7</u>		<u>159.97</u>
<b>CLEARCUTS</b>								
>75% Bare Ground				10.00	12.00	120.0	.18	21.60
50-75% Bare Ground				10.00	10.00	100.0	.14	14.00
25-50% Bare Ground				110.00	6.00	660.0	.09	59.40
<25% Bare Ground								
				<u>130.00</u>		<u>880.0</u>		<u>85.00</u>
<b>FORESTED AREAS</b>								
Rock				20.00				
Brush & Seedlings				490.00	.25	122.5	.12	14.70
Saplings & Poles				2,200.00	.05	110.0	.09	9.90
2nd-Growth				840.00	.03	25.2	.07	1.76
Hardwoods				1,840.00	.02	36.8	.08	2.94
Old-Growth				260.00	.01	2.6	.05	.13
Water				5.00				
				<u>5,655.00</u>		<u>297.1</u>		<u>29.43</u>
<b>BURNS</b>								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				650.00	11.30	2,345.0	.06	440.70
<b>TOTALS</b>								
Total Forest Land Acres				<u>6,910.00</u>		<u>5,445.8</u>		<u>990.12</u>
Gross Acres Forest Land = 6,910 Gross Sq. Miles = 10.8 Total Miles Perennial Stream = 1.85/mi <sup>2</sup> Total Miles Road = 84 = 7.8/mi <sup>2</sup>								
Mean Annual Erosion = 5,445.8 Tons/Yr. Gross Erosion = 967.23 Tons/mi <sup>2</sup> /Yr. Sediment Delivery Ratio = .95								
Mean Annual Sediment = 990.12 Tons/Yr. Gross Sediment = 92.60 Ton/mi <sup>2</sup> /Yr. Bedload = 15.43 Tons/mi <sup>2</sup> /Yr.								

TABLE VII-11  
KILCHIS RIVER - UPPER MAIN STEM  
EROSION AND SEDIMENT  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		1	20	2	1.20	2.4	.06	.14
Gravel 2 Track		150	35	611	.80	488.8	.10	48.88
Secondary 1½ Track		110	45	576	2.00	1,152.0	.05	57.60
Spurs 1 Track		40	25	116	3.90	452.4	.07	31.10
Skid Rds. ½ Track		45	15	78	4.50	351.0	.10	35.10
				<u>1,383</u>		<u>2,446.6</u>		<u>162.82</u>
TRAILS								
Fire Trails		5	15	8	.70	5.6	.05	.28
Rail Grades Abandoned		6	10	7	.25	1.7	.02	.03
Power Lines		3	30	10	.40	4.0	.08	.32
Motorbike Trails		3	3	<u>1</u>	6.00	<u>6.0</u>	.12	<u>.72</u>
				26		17.3		1.35
LANDSLIDES								
Upper 1/3 Slope				399	6.00	2,394.0	.08	205.00
Middle 1/3 Slope				241	4.00	964.0	.09	86.76
Lower 1/3 Slope				<u>132</u>	5.00	<u>660.0</u>	.17	<u>112.20</u>
				772		4,018.0		403.90
STREAMS								
Channel Bank		7	5	4	40.00	160.0	.70	112.00
Channel Bottoms		3	15	5	30.00	150.0	.50	75.00
Flood Plain Scour		2	10	<u>2</u>	50.00	<u>100.0</u>	.25	<u>25.00</u>
				11		410.0		212.00
CLEARCUTS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground								
<25% Bare Ground								
FORESTED AREAS								
Rock				470				
Brush & Seedlings				2,290	.20	458.0	.12	54.96
Saplings & Poles				5,028	.05	251.4	.09	22.63
2nd-Growth				1,320	.04	52.8	.07	3.70
Hardwoods				3,610	.03	108.3	.08	8.66
Old Growth				760	.01	7.6	.05	.38
Water				<u>10</u>				
				13,488		878.1		90.33
BURNS								
>75% Bare Ground				30	2.00	60.0	.12	7.20
50-75% Bare Ground				20	1.50	30.0	.10	3.00
25-50% Bare Ground				2,690	1.00	2,690.0	.05	134.50
<25% Bare Ground				<u>2,980</u>	.50	<u>1,490.0</u>	.03	<u>44.70</u>
				5,720		4,270.0		190.40
Total Forest Land Acres				<u>21,400</u>	<u>12,040.0</u>		<u>1,060.80</u>	
Gross Acres Forest Land = 21,400				Mean Annual Erosion = 12,040 Tons/Yr.			Mean Annual Sediment = 1.0 Tons/mi <sup>2</sup> /Yr.	
Gross Sq. Miles = 53.44				Gross Erosion = 360.05 Tons/Mi <sup>2</sup> /Yr.			Gross Sediment = 32.0 Tons/mi <sup>2</sup> /Yr.	
Total Miles Perennial Stream = 44 = 1.32/mi <sup>2</sup>				Sediment Delivery Ratio = .088%			Suspended Sediment = 17.0 Tons/mi <sup>2</sup> /Yr.	
Total Miles Road = 363 = 10.86/mi <sup>2</sup>							Bedload = 15.0 Tons/mi <sup>2</sup> /Yr.	

TABLE VII-12  
WILSON RIVER - LITTLE NORTH FORK  
EROSION AND SEDIMENT  
FORESTED LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		2	--	8.00	1.00	8.0	.010	0.08
Gravel 2 Track		32	--	172.00	0.55	94.6	.020	1.89
Secondary 1½ Track		51	--	342.00	1.64	560.4	.060	35.47
Spurs 1 Track		34	--	116.00	2.53	293.6	.060	17.62
Skid Roads ½ Track		20	--	32.00	3.50	112.0	.050	5.60
				670.00		1,068.6		60.66
TRAILS								
Fire Trails		2	--	18.00	1.80	32.4	.020	0.65
Rail Grade Used		5	--	--	0.40	3.6	.010	0.04
Rail Grades Abandoned		10	--	1.00	0.30	0.3	.020	0.01
Transmission Lines		1	--	8.00	1.30	10.4	.020	0.21
Motorbike Trails		12	--	14.00	2.40	33.6	.040	1.34
				41.00		80.3		2.25
LANDSLIDES								
Upper 1/3 Slope		--	--	44.00	3.70	162.8	.200	32.56
Middle 1/3 Slope		--	--	11.00	4.30	47.3	.400	18.92
Lower 1/3 Slope		--	--	13.00	4.90	63.7	.650	41.41
				69.00		273.8		92.89
STREAMS								
Channel Bank		--	--	3.00	41.60	125.0	.800	100.00
Channel Bottoms		--	--	5.00	15.00	75.0	.950	71.25
Flood Plain Scour		--	--	1.00	6.00	6.0	.600	3.6
				9.00		206.0		174.85
CLEARCUTS								
>75% Bare Ground		--	--	20.00	9.00	180.0	.040	7.20
50-75% Bare Ground		--	--	110.00	4.10	452.0	.030	13.56
25-50% Bare Ground		--	--	190.00	2.33	442.0	.020	8.84
<Bare Ground		--	--	180.00	0.66	118.0	.010	1.18
				500.00		1,192.0		30.78
FORESTED AREAS								
Brush and Seedlings		--	--	1,450.00	0.22	316.0	.020	6.32
Saplings and Poles		--	--	4,230.00	0.07	296.1	.015	4.44
Mature 2nd Growth		--	--	2,110.00	0.06	126.6	.010	1.27
Hardwoods		--	--	3,420.00	0.04	136.8	.002	0.27
Old Growth		--	--	2,670.00	0.01	26.7	.001	0.03
				13,880.00		902.2		12.30
BURNS								
>75		--	--	--	--	--	--	--
50-75		--	--	--	--	--	--	--
25-50		--	--	190.00	4.50	855.5	.020	17.11
<25		--	--	1,010.00	2.50	2,525.0	.010	25.25
Rock		--	--	35.00	0.00	--	--	--
Water (Streams 10'+ Wide)	--	--	--	18.00	0.00	--	--	--
				1,253.00		3,380.5		42.36
Total Acres Forest Lands				16,422.00		7,103.4		416.09
Gross Acres Forest Land = 16,422				Gross Sediment = 416.09		Gross Sediment = 16.21T/mi <sup>2</sup>		
Gross Sq. Miles = 25.67				Gross Erosion = 7,103.40		Suspended Sediment = 12.47 T/Mi <sup>2</sup>		
Total Miles Perennial Streams = 17 = .66mi/mi <sup>2</sup>				Gross Erosion = 276.72T/Mi <sup>2</sup>		Bedload = 3.8T/mi <sup>2</sup>		
Total Miles Road = 139				Sediment Delivery Rate = .058				
Watershed Road Ratio = 5.41 mi/mi <sup>2</sup>								

TABLE VII-13  
WILSON RIVER-LOWER MAIN STEM  
EROSION AND SEDIMENT  
FORESTED LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		18	--	86.00	1.8	154.3	.06	9.29
Gravel 2 Track		140	--	764.00	.7	534.8	.10	53.48
Secondary 1½ Track		372	--	2,480.00	1.4	3,472.0	.06	212.48
Spurs 1 Track		95	--	319.00	2.0	638.0	.07	44.66
Skid Roads ½ Track		175	--	276.00	3.2	883.2	.08	70.66
				<u>3,925.00</u>		<u>5,682.0</u>		<u>390.57</u>
TRAILS								
Fire Trails		18	--	83.00	1.5	124.5	.05	6.23
Rail Grades Used		--	--	--	--	--	--	--
Rail Grades Abandoned		--	--	--	--	--	--	--
Transmission Lines		40	--	218.00	0.9	196.2	.08	13.70
Motorbike Trails		90	--	109.00	2.1	228.9	.15	34.34
				<u>410.00</u>		<u>549.6</u>		<u>56.27</u>
LANDSLIDES								
Upper 1/3 Slope		--	--	381.00	5.82	2,219.8	.11	243.96
Middle 1/3 Slope		--	--	140.00	10.94	1,532.0	.30	458.76
Lower 1/3 Slope		--	--	166.00	5.94	985.6	.45	440.64
				<u>687.00</u>		<u>4,737.4</u>		<u>1,143.36</u>
STREAMS								
Channel Bank		--	--	12.00	360.00	4,320.0	.53	2,272.00
Channel Bottoms		--	--	30.00	228.00	6,840.0	.47	3,230.65
Flood Plain Scour		--	--	6.00	42.00	252.0	.60	151.20
CLEARCUTS								
>75% Bare Ground		--	--	20.00	8.80	176.0	.12	21.12
50-75% Bare Ground		--	--	60.00	4.50	270.0	.15	40.50
25-50% Bare Ground		--	--	180.00	2.60	468.0	.10	46.80
<25% Bare Ground		--	--	110.00	0.50	55.0	.05	2.75
				<u>370.00</u>		<u>969.0</u>		<u>111.07</u>
FORESTED AREAS								
Brush and Seedlings		--	--	4,270.00	0.20	854.0	.12	102.48
Saplings and Poles		--	--	13,140.00	0.10	1,314.0	.08	105.12
Mature 2nd-Growth		--	--	3,810.00	0.07	266.7	.09	24.00
Hardwoods		--	--	9,980.00	0.03	299.4	.11	32.93
Old Growth		--	--	5,100.00	0.02	102.0	.10	10.20
				<u>36,300.00</u>		<u>2,836.0</u>		<u>274.73</u>
BURNS								
>75		--	--	220.00	6.50	1,430.0	.10	143.00
50-75		--	--	10.00	4.10	41.0	.08	3.28
25-50		--	--	2,620.00	3.50	9,170.0	.06	550.20
<25		--	--	2,140.00	2.20	4,700.0	.04	188.32
Rock		--	--	870.00	0.00	0.0	--	--
Water (Streams 10' + Wide)		--	--	120.00	0.00	0.0	--	--
				<u>5,980.00</u>		<u>15,341.0</u>		<u>8,514.80</u>

Total Acres Forest Land	<u>47,720.00</u>	<u>41,527.0</u>	<u>16,144.65</u>
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Gross Acres Forest Land = 47,720	Gross Sediment = 8,514.75	Gross Sediment = 114.2T/mi <sup>2</sup>
Gross Sq. Miles = 74.56	Gross Erosion = 41.527	Suspended Sediment = 38.4T/mi <sup>2</sup>
Total Miles Perennial Streams = 60	Gross Erosion = 557.07T/mi <sup>2</sup>	Bedload = 75.8T/mi <sup>2</sup>
= .80mi/mi <sup>2</sup>		Sediment Delivery Rate = .20530
Total Miles Road = 800		
Watershed Road Ratio = 10.73 mi/mi <sup>2</sup>		

TABLE VII-14  
UPPER WILSON RIVER  
EROSION AND SEDIMENT  
FORESTED LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/AC/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>								
Paved Roads		7	--	37.00	1.60	59.2	.09	5.3
Gravel 2 Track		328	--	1,791.00	0.60	1,074.6	.10	107.5
Secondary 1½ Track		647	--	4,311.00	1.40	6,035.4	.05	288.6
Spurs 1 Track		121	--	413.00	2.10	867.3	.08	69.4
Skid Roads ½ Track		220	--	346.00	2.90	1,003.4	.06	60.2
				<u>6,898.00</u>		<u>9,039.9</u>		<u>531.0</u>
<b>TRAILS</b>								
Fire Trails		23	--	232.00	1.70	394.4	.05	19.7
Rail Grades Used		--	--	--	--	--	--	--
Rail Grades Abandoned		--	--	--	--	--	--	--
Transmission Lines		14	--	74.00	2.80	207.2	.06	12.4
Motorbike Trails		178	--	216.00	1.80	388.8	.09	35.0
				<u>522.00</u>		<u>990.4</u>		<u>67.1</u>
<b>LANDSLIDES</b>								
Upper 1/3 Slope		--	--	643.00	5.40	3,472.2	.10	347.2
Middle 1/3 Slope		--	--	166.00	9.80	1,626.8	.20	325.4
Lower 1/3 Slope		--	--	367.00	5.90	2,172.3	.30	651.7
				<u>1,176.00</u>		<u>7,271.3</u>		<u>1,324.3</u>
<b>STREAMS</b>								
Channel Bank		--	--	8.00	225.00	1,800.0	.52	940.0
Channel Bottoms		--	--	20.00	85.00	1,700.0	.54	915.0
Flood Plain Scour		--	--	4.00	20.00	80.0	.50	40.0
				<u>32.00</u>		<u>3,580.0</u>		<u>1,895.0</u>
<b>CLEARCUTS</b>								
>75% Bare Ground		--	--	--	--	--	--	--
50-75% Bare Ground		--	--	--	--	--	--	--
25-50% Bare Ground		--	--	--	--	--	--	--
<25% Bare Ground		--	--	--	--	--	--	--
<b>FORESTED AREAS</b>								
Brush and Seedlings		--	--	4,480.00	0.18	806.40	.12	96.8
Saplings and Poles		--	--	18,470.00	0.11	2,068.40	.08	165.5
Mature 2nd Growth		--	--	6,020.00	0.08	481.60	.07	33.7
Hardwoods		--	--	4,490.00	0.02	89.80	.06	5.4
Old Growth		--	--	5,520.00	0.01	55.20	.05	2.7
				<u>38,980.00</u>		<u>3,501.40</u>		<u>304.1</u>
<b>BURNS</b>								
>75		--	--	200.00	4.20	840.00	.08	67.2
50-75		--	--	40.00	2.50	100.00	.06	6.0
25-50		--	--	5,410.00	0.60	3,024.30	.04	121.0
<25		--	--	2,430.00	0.20	486.00	.02	9.7
Rock		--	--	1,160.00	0.00	--	--	--
Water (Streams 10'+ Wide)		--	--	112.00	0.00	--	--	--
				<u>9,352.00</u>		<u>4,450.00</u>		<u>203.9</u>
<b>Total Acres - Forest Lands</b>				<u>56,960.00</u>		<u>28,833.00</u>		<u>4,325.4</u>

Gross Acres Forest Land = 56,960  
Gross Sq. Miles = 89.0  
Total Miles Perennial Streams = 41  
= 46mi/mi<sup>2</sup>  
Watershed Road Ratio = 14.87mi/mi<sup>2</sup>

Gross Sediment = 4,325.4  
Gross Erosion = 28,833.3  
Gross Erosion = 323.97T/mi<sup>2</sup>

Gross Sediment = 48.6T/mi<sup>2</sup>  
Suspended Sediment = 27.4T/mi<sup>2</sup>  
Bedload = 19.4T/mi<sup>2</sup>  
Sediment Delivery Rate = .150

TABLE VII-15  
MAIN STEM TRASK RIVER  
EROSION AND SEDIMENT ALLOCATION  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>								
Paved Roads		8.0		29	1.50	43.5	.10	4.35
Gravel 2 Track		580.0		3,915	1.90	6,678.5	.14	963.98
Secondary 1½ Track		621.0		4,140	2.20	9,108.0	.15	1,321.60
Spurs 1 Track		170.0		824	2.80	2,307.2	.15	346.08
Skid Rds. ½ Track		220.0		400	3.00	1,200.0	.11	132.00
				<u>9,308</u>		<u>19,337.2</u>		<u>2,768.01</u>
<b>TRAILS</b>								
Fire Trails		20.0		78	2.10	163.8	.05	8.19
Rail Grades Used								
Rail Grades Abandoned	72.5			97	0.30	29.1	.02	0.58
Transmission Lines	12.0			61	0.80	48.8	.06	2.93
Motorbike Trails	80.0			68	3.70	251.6	.18	45.29
				<u>304</u>		<u>493.3</u>		<u>56.90</u>
<b>LANDSLIDES</b>								
Upper 1/3 Slope				97	5.00	435.0	.40	174.00
Middle 1/3 Slope				65	10.00	650.0	.70	455.00
Lower 1/3 Slope				30	7.00	560.0	.90	504.00
				<u>192</u>		<u>1,645.0</u>		<u>1,133.00</u>
<b>STREAMS</b>								
Channel Bank				15	424.70	6,371.2	.87	5,532.64
Channel Bottoms				10	240.00	7,200.0	.40	2,880.00
Flood Plain Scour				46	52.00	3,432.0	.25	858.00
				<u>71</u>		<u>17,363.2</u>		<u>9,290.64</u>
<b>CLEARCUTS</b>								
>75% Bare Ground				10	6.10	183.0	.15	27.45
50-75% Bare Ground				120	4.30	516.0	.12	61.92
25-50% Bare Ground				340	2.00	650.0	.10	64.00
<25% Bare Ground				40	0.50	45.0	.05	2.25
				<u>510</u>		<u>1,394.0</u>		<u>155.62</u>
<b>FORESTED AREAS</b>								
Brush and Seedlings				6,340	0.28	3,789.2	.10	178.92
Saplings and Poles				19,400	0.19	3,686.0	.11	405.46
Mature 2nd-Growth				6,420	0.09	577.0	.12	69.36
Hardwoods				9,220	0.03	278.1	.10	27.81
Old Growth				6,920	0.01	69.2	.08	5.54
				<u>48,350</u>		<u>6,399.3</u>		<u>687.09</u>
<b>BURNS</b>								
>75% Bare Ground				100	6.70	1,072.0	.12	128.64
50-75% Bare Ground				90	4.50	405.0	.10	40.50
25-50% Bare Ground				3,930	3.20	18,976.0	.08	1,519.08
<25% Bare Ground				4,210	2.80	11,788.0	.06	707.28
				<u>9,130</u>		<u>32,241.0</u>		<u>2,395.50</u>
<b>Total Acres - Forest Lands</b>				<u>67,865</u>		<u>78,873.0</u>		<u>16,486.76</u>

Gross Acres = 69,865

Gross Sq. Mi. = 109.25

Total Miles Perennial Streams = 75

Watershed: Road Ratio = 14.64 mi/mi<sup>2</sup>

Total Miles Road = 1.599

Watershed: Stream Ratio = 69 mi/mi<sup>2</sup>

Gross Sediment = 16,486.76 T/Yr.

Gross Erosion = 78,873.0 T/Yr.

Gross Erosion = 718.57 T/mi<sup>2</sup>/yr.

Gross Erosion = 718.57 T/mi<sup>2</sup>/yr.

Gross Sediment = 130.9 T/mi<sup>2</sup>

Suspended Sediment = 121.75 T/mi<sup>2</sup>

Bedload = 29.15 T/mi<sup>2</sup>

Sediment Delivery Ratio = .21

TABLE VII-16  
EAST FORK TRASK RIVER  
EROSION AND SEDIMENT ALLOCATION  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
<b>ROADS</b>								
Paved Roads								
Gravel 2 Track	68.0			413	2.00	824.0	.15	123.60
Secondary 1½ Track	124.0			826	3.40	2,972.2	.20	594.44
Spurs 1 Track	18.0			87	4.60	401.1	.17	68.19
Skid Roads ½ Track	160.0			291	3.20	931.2	.10	93.12
				<u>1,617</u>		<u>5,128.3</u>		<u>879.35</u>
<b>TRAILS</b>								
Fire Trails	5.0			12	2.00	24.0	.09	2.14
Rail Grades Used								
Rail Grades Abandoned	7.5			9	1.60	14.4	.05	0.72
Transmission Lines	4.5			11	2.90	43.5	.08	3.48
Motorbike Trails	18.0			44	5.50	242.6	.10	24.20
				<u>67</u>		<u>324.5</u>		<u>30.50</u>
<b>LANDSLIDES</b>								
Upper 1/3 Slope				64	7.00	476.0	.50	238.00
Middle 1/3 Slope				3	11.00	55.0	.80	44.00
Lower 1/3 Slope				25	12.00	300.0	.90	270.00
				<u>92</u>		<u>831.0</u>		<u>552.00</u>
<b>STREAMS</b>								
Channel Bank				4	531.33	3,188.0	.93	2,967.39
Channel Bottoms				15	223.67	2,355.0	.24	815.00
Flood Plain Scour				2	110.00	220.0	.20	44.00
				<u>21</u>		<u>6,763.0</u>		<u>3,826.39</u>
<b>CLEARCUTS</b>								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground								
<Bare Ground								
<b>FORESTED AREAS</b>								
Brush and Seedlings				2,708	1.36	3,790.0	.10	378.00
Saplings and Poles				6,670	0.30	2,001.0	.08	160.08
Mature 2nd-Growth				469	0.09	41.4	.09	3.73
Hardwoods				1,489	0.06	88.8	.07	6.22
Old-Growth				1,299	0.02	25.8	.05	1.29
				<u>12,635</u>		<u>5,947.0</u>		<u>549.22</u>
<b>BURNS</b>								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				2,620	2.68	7,026.0	.15	1,033.90
<25% Bare Ground				1,660	1.80	2,992.0	.12	359.04
Rock				42				
Water (Streams 10'+ wide)				10				
				<u>4,332</u>		<u>10,018.0</u>		<u>1,392.94</u>
<hr/>								
Total Acres- Forest Lands				<u>18,674</u>		<u>29,011.8</u>		<u>7,230.20</u>

Gross Acres = 18,674  
Gross Sq. Mi. = 29.42  
Total Miles Perennial Streams = 29  
Watershed: Road Ratio = 12.58 mi/mi<sup>2</sup>  
Total Miles Road = 370  
Watershed: Stream Ratio = 1 mi/mi<sup>2</sup>

Gross Sediment = 7,230.2 T/yr.  
Gross Erosion = 29,011.8 T/Yr.  
Gross Erosion = 985.79 T/Ac./yr.

Gross Sediment = 246.45 Ton/mi<sup>2</sup>/yr.  
Suspended Sediment = 218.75 T/mi<sup>2</sup>/yr.  
Bedload = 27.7 T/mi<sup>2</sup>/yr.  
Sediment Delivery Rate = .25

TABLE VII-17  
SOUTH FORK TRASK RIVER  
EROSION AND SEDIMENT ALLOCATION  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads								
Gravel 2 Track		42.0		255	0.30	76.50	.15	11.48
Secondary 1½ Track		105.0		700	0.50	350.00	.10	35.00
Spurs 1 Track		12.0		58	1.10	63.80	.12	7.66
Skid Roads ½ Track		40.0		73	1.20	87.60	.09	7.88
				<u>1,086</u>		<u>577.9</u>		<u>65.02</u>
TRAILS								
Fire Trails		7.0		17	0.90	15.30	.05	0.77
Rail Grades Used								
Rail Grades Abandoned								
Transportation Lines	3.5			28	1.10	30.80	.09	2.77
Motorbide Trails	14.0			32	2.80	89.60	.15	13.44
				<u>77</u>		<u>135.70</u>		<u>16.98</u>
LANDSLIDES								
Upper 1/3 Slope				143	2.20	314.60	.20	62.92
Middle 1/3 Slope				34	5.10	173.40	.15	26.01
Lower 1/3 Slope				59	4.30	253.70	.30	76.11
				<u>236</u>		<u>741.70</u>		<u>165.04</u>
STREAMS								
Channel Bank				5	103.80	319.00	.40	208.44
Channel Bottoms				12	79.10	950.00	.54	510.00
Flood Plain Scour				2	30.00	60.00	.20	12.00
				<u>19</u>		<u>1,529.00</u>		<u>730.44</u>
CLEARCUTS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground								
<25% Bare Ground								
FORESTED AREAS								
Brush and Seedlings				1,890	0.07	128.80	.80	12.88
Saplings and Poles				3,840	0.05	192.00	.09	17.23
Mature 2nd-Growth				210	0.03	6.30	.08	0.50
Hardwoods				1,860	0.02	37.20	.07	2.60
Old-Growth				620	0.01	6.20	.05	0.31
				<u>8,370</u>		<u>370.50</u>		<u>33.52</u>
BURNS								
>75% Bare Ground								
50-75% Bare Ground				30	1.50	45.00	.10	4.50
25-50% Bare Ground				1,150	0.67	765.97	.06	45.96
<25% Bare Ground				2,150	0.37	790.00	.04	31.60
Rock				62				
Water (Streams 10+ wide)				10				
				<u>3,402</u>		<u>1,600.9</u>		<u>82.06</u>

Total Acres - Forest Lands

13,190

4,955.7

1,092.80

Gross Acres = 13,190

Gross Sq. Mi. = 20.61

Total Miles Perennial Streams = 29

Waterbed: Road Ratio = 9.66 mi/mi<sup>2</sup>

Total Miles Road = 199

Watershed: Stream Ratio = 1.21 mi/mi<sup>2</sup>

Gross Sediment = 1,092.8 T/Yr.

Gross Erosion = 4,955.77 T/yr.

Gross Erosion = 240.45 T/mi<sup>2</sup>/yr.

Gross Sediment = 52.9 T/mi<sup>2</sup>/yr.

Suspended Sediment = 27.7 T/yr.

Bedload = 25.2 T/mi<sup>2</sup>/Yr.

Sediment Delivery Rate = 22

TABLE VII-18  
TILLAMOOK RIVER  
EROSION AND SEDIMENT ALLOCATION  
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		9.0	40.0	43.6	1.15	50.4	.09	4.5
Gravel 2 Track		351.0	50.0	2,127.2	.45	957.2	.22	209.0
Secondary 1½ Track		120.0	60.0	872.7	1.38	1,204.3	.20	240.0
Spurs 1 Track		30.0	30.0	109.0	2.84	309.6	.15	46.5
Skid Rds. ½ Track		120.0	15.0	218.2	3.90	850.9	.30	255.0
				3,370.7		3,372.4		755.0
TRAILS								
Fire Trails								
Rail Grades Used								
Rail Grades Abandoned		45.0	10.0	54.5	.83	45.2	.08	3.60
Transmission Lines		10.0	40.0	48.0	1.23	59.0	.15	8.60
Motorbike Trails		5.0	5.0	3.1	5.16	15.9	.24	3.80
				105.6		120.1		16.00
LANDSLIDES								
Upper 1/3 Slope				92.0	4.35	400.2	.39	150.00
Middle 1/3 Slope				315.0	2.86	900.9	.56	504.00
Lower 1/3 Slope				184.0	3.59	660.5	.20	528.00
				591.0		1,961.6		1,182.00
STREAMS								
Channel Bank		13.6	4.0	6.6	393.94	2,600.0	.90	2,340.00
Channel Bottom		2.8	7.5	2.5	160.00	400.0	.95	380.00
Flood Plain Scour		7.0	12.5	10.6	47.17	500.0	.42	209.00
				19.7		3,500.0		2,929.00
CLEARCUTS								
>75% Bare Ground				860.0	12.08	11,008.0	.10	1,100.80
50-75% Bare Ground				890	7.06	6,764.0	.08	540.70
25-50% Bare Ground				2,070.0	4.04	9,108.0	.03	273.24
<25% Bare Ground				1,690.0	1.07	2,873.0	.02	56.89
				5,510.0		29,753.0		1,971.63
FORESTED AREAS								
Brush & Seedlings				2,640.0	.21	534.4	.12	69.97
Saplings & Poles				13,795.5	.14	1,931.3	.08	154.50
Mature 2nd-Growth				3,970.0	.06	238.3	.05	11.92
Hardwoods				2,330.0	.07	163.1	.04	6.52
Old-Growth				1,150.0	.03	34.5	.03	1.04
				23,885.5		2,921.6		243.95
Sand Beach				40.0	.00	.0		.00
Water				47.5	.00	.0		.00
				Total 33,570.0		41,628.7		7,097.58

Forest Land Total = 33,970 Acres

Forest Land Total = 52.45 Miles

Perennial Stream = 70 miles = 1.33/mi<sup>2</sup>

Miles of Road = 630 = 12.0/mi.<sup>2</sup>

Close examination of the foregoing data indicates that there are terrestrial and instream erosion and sediment problems. It is difficult to determine the difference when the sediment reaches the bay. Both sources are important contributors. However, the instream contribution becomes quite significant due to higher delivery ratios.

There are two effects on the stream system of terrestrial source sediment which reaches stream systems. First, the sediment carried by a stream from a land area source tends to dissipate the energy of the water, especially during flood periods, thus reducing the capacity of the flowing water to dislodge streambank and streambed particles. This sediment also serves as an abrasive to increase the effectiveness of the flowing water as an erosive agent. It becomes difficult to ascertain where one effect leaves off and the other begins, since the two are inter-related. The actual dynamics of this process is much more complex and beyond the scope of this study. However, to summarize the situation, a stream will continue to erode soil particles and transport them some distance as long as it retains the energy to do so. The stream systems in Tillamook Bay drainage basin have large energy capacities because of gradient, volume of runoff, and short duration of accumulation for runoff. These conditions, when coupled with the soils and geology of the basin, result in fairly high geologic erosion and sediment delivery rates. The contribution of stream systems in the forest resource area are emphasized on Table VII-19.

Table VII-19 STREAM SYSTEM EROSION AND SEDIMENT PRODUCTION.  
FOREST LANDS

Subbasin	Stream System Mean Erosion Tons Per Year	Stream System Mean Sediment Tons Per Year
Tillamook	3,500	2,929
Miami	3,026	760
Upper Kilchis	410	212
Lower Kilchis	1,135	1,006
Little S. Fk. Kilchis	215	160
Little N. Fk. Wilson	206	171
Upper Wilson	3,580	1,895
Lower Wilson	11,412	5,654
Main Stem Trask	17,003	9,290
E. Fork Trask	6,763	3,826
S. Fork Trask	1,529	730
TOTAL	48,799 t/yr	26,633 t/yr

Note: The stream system contributes 17.3 percent of the mean annual gross erosion and 51.5 percent of the mean annual gross fluvial sediment.

Erosion and Sediment Intensity by Subbasin (Table VII-20) and A Summary of Landslides and Roads (Table VII-21) are shown next. These tables summarize the major erosion and sediment problems on forest lands by subbasin.



Landslide erosion on upper forest land slopes.



Roadside erosion--Forest lands.



Mile 7 on the Wilson Highway--Debris-choked tributary stream.



Closeup of above debris-choked stream.

Table VII-20 - EROSION AND SEDIMENT INTENSITY BY SUBBASIN<sup>1/</sup>  
FOREST LANDS

Subbasin	Area Miles <sup>2</sup>	Stream Miles/ Mile <sup>2</sup>	Roads/ Mile <sup>2</sup>	Landslides/ Mile <sup>2</sup>	Gross Erosion T./Mi. <sup>2</sup> /Yr.	Erosion Load Rank	Gross Sediment T./Mi. <sup>2</sup> /Yr.	Sediment Load Rank
Tillamook	52.45	1.33	12.00	2.59	793.68	9	135.30	9
Miami	37.95	1.19	8.85	16.07	539.97	5	53.70	5
Upper Kilchis	33.44	1.32	10.86	15.40	360.05	4	32.00	2
Lower Kilchis	23.45	1.07	10.45	8.96	578.45	7	98.54	7
South Fork Kilchis	10.80	1.85	7.80	12.13	967.23	10	92.60	6
Lower Wilson	74.56	.80	10.73	9.24	557.07	6	114.20	8
Upper Wilson	89.00	.46	14.87	13.21	323.97	3	46.80	3
North Fork Wilson	25.67	.66	5.41	3.54	276.72	2	16.21	1
Main Trask	109.25	.69	14.64	4.15	718.57	8	150.90	10
East Fork Trask	29.42	1.00	12.58	6.66	985.79	11	246.45	11
South Fork Trask	20.61	1.21	9.66	22.95	240.45	1	52.90	4
Total	506.60							

<sup>1/</sup> Erosion and sediment load expressed as mean tons per square mile per year ranked by subwatershed are rated  
Lowest contributor (1) to highest (11).

Table VII-21 - SUMMARY OF LANDSLIDES AND ROADS\*(FOREST LANDS)

RIVER	BRANCH	MAN-CAUSED LANDSLIDES			NATURAL-CAUSED LANDSLIDES			TOTAL	Lower 1/3 Slope	Middle 1/3 Slope	Upper 1/3 Slope	TOTAL	Total for Man-Caused and Natural	Road Miles
		Upper 1/3 Slope	Middle 1/3 Slope	Lower 1/3 Slope	Upper 1/3 Slope	Middle 1/3 Slope	Lower 1/3 Slope							
Trask	Main	163	127	146	11	3	3	436	11	3	17	453	1,599	
	S. Fork	282	66	118	5	2	0	466	5	2	7	473	199	
	E. Fork	133	10	47	4	0	2	190	4	0	6	196	370	
	Total	578	203	311	20	5	5	1,092	20	5	30	1,122	2,168	
Wilson	Lower	363	133	163	18	8	4	659	18	8	30	689	800	
	Upper	625	161	362	18	5	5	1,148	18	5	28	1,176	1,323	
	Forks Little N. Fork	43	10	13	15	3	10	63	15	3	28	91	139	
	Total	1,031	304	538	51	16	19	1,870	51	16	86	1,956	2,262	
Kilchis	Lower	131	40	31	1	4	3	202	1	4	8	210	245	
	Upper	255	158	84	11	3	4	497	11	3	18	515	363	
	Little S. Fork	61	34	34	0	2	0	129	0	2	2	131	84	
	Total	447	232	149	12	9	7	828	12	9	28	856	692	
Miami	Entire Basin	307	123	96	33	27	24	526	33	27	84	610	336	
Tillamook	Entire Basin	77	27	20	12	0	0	124	12	0	12	136	630	
								4,440			240	4,680	6,088	

\*Includes those landslides and roads visible on 2" = 1 mile, U-2 aircraft, false color, infrared photography dated 1975

By: Cliff Benoit, USFS, R-6, S&amp;PF 8-5-77

T 2 N

1 N

1 S

2

3

R 10 W

9

8

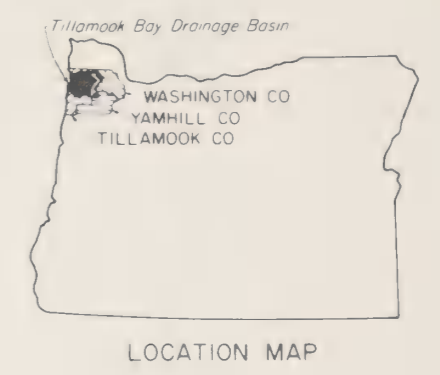
7

6

5

Ocean

Pacific

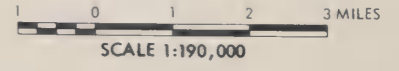


MEAN ANNUAL GROSS EROSION & SEDIMENT RATES

SUB BASIN	AREA SQ. MI.	GROSS EROSION RATE-TON/MI. <sup>2</sup> /YR.	GROSS SEDIMENT RATE-TONS/MI. <sup>2</sup> /YR.
Tillamook	52.45	793.68	135.30
Miami	37.95	539.97	53.70
Upper Kilchis	33.44	360.05	32.00
Lower Kilchis	23.45	578.45	98.54
S. Fk. Kilchis	10.80	967.23	92.60
Lower Wilson	74.56	557.07	114.20
Upper Wilson	89.00	323.97	46.80
N.FK. Wilson	25.67	276.72	16.21
Main Trask	109.25	718.57	150.90
E.FK. Trask	29.42	985.79	246.45
S.FK. Trask	20.61	240.45	52.90
Total (Mean Annual)	506.60	286,245 Tons/year	51,603 Tons/year

**FOREST LAND  
MEAN ANNUAL GROSS EROSION  
AND SEDIMENT RATES  
TILLAMOOK BAY DRAINAGE BASIN  
TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES  
OREGON**

JANUARY 1978



Source:  
Base map furnished by Oregon State Staff.  
Thematic detail compiled by C. R. Benoit, Hydrologist, USFS 1-19-78  
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR 97209



# TILLAMOOK BAY

## SURFACE SAMPLES

The major nonopaque heavy components in river bottom sediment samples <sup>1/</sup> are pyroxene group minerals and rock fragments. Kulm, et al. (1968, p. 168-169) also noted the dominance of pyroxene group minerals in Tillamook Bay rivers, although they did not report the abundance of rock fragments. The clinopyroxenes, augite plus diopside, comprise the bulk of the pyroxene group. Only trace amounts of orthopyroxenes, chiefly hypersthene, were noted. The rock fragments are grains with at least two constituents, usually a feldspar and/or a pyroxene, and a fine-grained or opaque "groundmass". The feldspar twinning, where observed, suggests a basic to intermediate composition, and most multiple constituent grains are classified as volcanic rock fragments. Small amounts of amphibole group minerals and of olivine also occur in most river sediment samples.

Sample sites and referenced locations are shown on Sample location and Data Map Figure VI-1.

## MINERALOGY OF THE BAY

The rivers entering Tillamook Bay do not show highly significant compositional differences. However, the Tillamook River may differ slightly from the other four rivers. Avolio (1973, p. 51-52), from X-ray diffraction patterns for heavy mineral separates from Tillamook Bay rivers, identified somewhat distinctive patterns for each river, with the Miami River seeming to differ significantly from the Trask, Wilson, and Kilchis Rivers.

Tidal river samples, on the average, show less rock fragments and pyroxenes and more amphibole and accessory minerals than river samples show. However, on an individual river basis, only the Tillamook and some of the combined Tillamook-Trask tidal river samples differ greatly from river samples. Tillamook-Trask tidal river samples from downstream of the entrance of the main Trask River show only a "river" composition; those upstream of this entrance show the increased percentages of amphiboles and accessory minerals that are reflected in tidal river averages. In general, from the Trask to the Miami tidal river samples, there is a continuation of the trends (decreasing pyroxenes, increasing rock fragments) suggested by river samples.

Compositional data for surface sediment samples from the Southwestern Margin of Tillamook Bay are characterized by rather extreme

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<sup>1/</sup> Tables of sample data are on file at the Soil Conservation Service, Federal Bldg., 16th Floor, 1220 S.W. 3rd Ave., Portland, Oregon

local variability. Although two samples were collected in 1974 and two in 1977, the variability seems to be spatial rather than temporal. On the average, samples along the Southwestern Margin show substantial increases in amphiboles, accessory minerals, and "others" over samples from river or tidal river areas. These increases are chiefly at the expense of pyroxene group minerals, which on the average, are 20 to 25 percent less abundant than in river or tidal river areas. Even in those samples (14-74 and 4-77) where pyroxenes are as abundant as in many river samples, amphiboles and accessory minerals tend to be present in amounts greater than in river samples.

Major compositional differences occur between samples from the Western Margin of Tillamook Bay and those from Tillamook Bay rivers. These differences are: (1) a 20 percent decrease in rock fragments, (2) a 200 to 600 percent increase in accessory minerals, and (3) a change in pyroxene group composition from almost 100 percent clinopyroxenes to about a 30:70 percent orthopyroxene (hypersthene): clinopyroxene ratio. In addition to these quantitative changes, significant qualitative changes occur. These changes are most apparent in the degree of grain rounding. In river and in most tidal river and Southwestern Margin samples, most grains are angular to subangular (Pettijohn, 1957, pp. 58-59), whereas in the Western Margin samples most grains are subrounded to well rounded. In addition, optically isotropic fringes, which are common on grains in river samples, are very rare on grains from Western Margin samples.

No highly significant quantitative or qualitative differences are apparent when Western Margin samples are divided into those from the "Bay" and those from the "Ocean" sides of Bayocean Peninsula. In addition, the data do not establish the significance of possible compositional trends along Bayocean Peninsula.

The composition of Central Bay samples may be discussed by dividing the Central Bay into "southern" and "northern" portions. For this presentation, the boundary has been established arbitrarily in about the vicinity of Sandstone Point. Based on composition alone, a case could be made for establishing the boundary between sample sites 33-74 and 31-74, but no significant difference in conclusions results from doing so.

The southern Central Bay has a composition that is generally similar to that in river samples, with the exception of slightly higher average clinopyroxene percentages and lower rock fragment percentages. These changes are accompanied by some improvement in grain rounding, although most grains are still subangular to subrounded at best.

In the northern part of the Central Bay, the composition changes include decreases in average pyroxene group abundance (and the appearance in most samples of measurable amounts of hypersthene) and increases in accessory minerals. These changes, in general, are accompanied by continued improvement in grain rounding, particularly in those samples north and west of sample site 33-74.

The possibility of east-west compositional changes within the Central Bay cannot be established unequivocally with the data presented here. In the southern part, however, such changes seem unlikely because of the similarity between samples on the eastern (28-76 and 13-75) and western (18-75) sides (see also data for core site 11-76). In the northern part, Avolio (1973, p. 51) noted a progressive change from east to west with the X-ray pattern for an easternmost sample resembling a pattern for Miami River sediments and the pattern for the westernmost sample similar to that for beach and dune samples from Bayocean Peninsula.

The composition of Eastern Margin samples is basically the same as that of adjacent river and tidal river samples. In the central part of the Eastern Margin from Kilchis Point to just north of Sandstone Point, some samples (44-77, 19-74, see also data for core samples 15-76-1a and 14-76-1a) located close to the shoreline have somewhat anomalous and highly variable compositions. Likewise, sample 35-76, at the lower end of Miami Cove differs from typical Miami River samples.

#### Discussion- Surface Sample Composition

Compositional data for surface sediment samples establish three possible sources of modern surface sediments in Tillamook Bay. The five major rivers draining the Coast Range east of Tillamook Bay may be combined as one source, hereafter referred to as the "river" or "riverine" source. This source is almost exclusively a provider of angular clinopyroxenes and volcanic rock fragments to Tillamook Bay. A second major source provides substantial amounts of rounded orthopyroxenes and probably accessory minerals to surface sediments along the Western Margin and in the northern part of the Central Bay. This source will be referred to as the "marine" or "oceanic" sediment source. Kulm, et al. (1968, p. 176-177), from heavy mineral analyses of beach sands along the Oregon coast, concluded that either the Columbia River drainage or drainage basins south of Tillamook Bay (or both) were the ultimate source of "marine" sediments in the Tillamook area.

Sediments from the river source, when exposed to depositional conditions where marine source sediments are found, would "lose" their volcanic rock fragments and become better rounded due to abrasion. These changes probably could not increase the orthopyroxene and accessory mineral contents in typical river source sediments to the levels observed in marine source sediments.

The third source is shoreline erosion and small streams draining sedimentary bedrock along the Southwestern and Eastern Margins of Tillamook Bay. This source, referred to as the "shoreline" source, has no absolutely unique quantitative or qualitative compositional attributes. If this source were of greater extent, or if the contributions from this source were large relative to those from rivers, it is possible that no marine source would be necessary. It does not seem, however, that the shoreline source is capable of providing all of the orthopyroxenes that are found in marine source sediment. The compositional variability in samples from the Southwestern Margin and from the Eastern Margin north of Kilchis Point is a reflection of a mixed shoreline and river source for the sediment.

### Core Samples

Core sample data include "heavy" component compositional analyses, stratigraphic descriptions, and radiocarbon ages. Unlike the surface sample data, which are most useful for showing area variations at the present time, core sample data establish the nature of changes with time (depth) at each core site. The selection of samples for detailed analyses for this purpose was based on the presence or absence of suitable materials (organic matter for radio-carbon analyses, etc.) and on field and laboratory descriptions of the stratigraphy at each core site. Although not every core sample could be analyzed, the major changes with time at each site are believed to have been determined.

### Core Sample Composition

The percentages of nonopaque "heavy" components in core samples from Tillamook Bay are described with emphasis on emphasizing areal variations in composition among the core sites and on stratigraphic variations at a core site. In presenting areal variations, it should be noted that comparisons among core sites may be based on samples from different depths.

Areal and stratigraphic compositional variations at and among core sites are summarized in Map Figure VI-1 Sample Locations and Data. The probable source(s) of sediment for each sample analyzed is designated by "R" for river, "M" for marine and "S" for shoreline, followed by the depth, in meters, of the sample below the sediment surface. The source of sediment is interpreted only for those samples from the upper or Holocene part of the sediment fill in Tillamook Bay.

Stratigraphic differences in the source of sediments are indicated by compositional data at some core sites. The apparent exceptions are core sites 2, 4, and 8-76, where only river source sediments were identified, and core sites 1, 13, 14, and 15, where the upper sediment fill was relatively thin and only a single sample may have been analyzed. Core sites with uniform river sediment sources are generally well toward the upper end of Tillamook Bay, and they usually are remote from possible shoreline sources. Cores from near the shoreline (5 and 7-76) in the upper bay show a mixed river plus shoreline (RS) source, or sediments whose source varies from river to river plus shoreline at different depths.

Compositional differences with depth at core sites in Tillamook Bay south of Sandstone Point are shown by data from core sites 9, 16, 10, and 11-76. The general picture that emerges from these data includes: (1) a river source for deep samples, (2) a river plus marine (RM) or marine plus river (MR) source for intermediate depth samples, (3) a river source for shallow surface samples from the upper or eastern side of the bay, and (4) a marine plus river source for the shallow surface sample from the western side of the bay.

North of Sandstone Point, strictly river source sediments occur at depth only in cores from Miami Cove, where intermediate and shallow surface samples show mixed river, river plus shoreline, or river plus marine sources. Core sediments from the main part of Tillamook Bay north of Sandstone Point typically start with a mixed river plus shoreline composition, and seem to become more marine toward the surface.

#### Discussion-Core Sample Composition

Core sample compositional analyses generally reveal the same sediment sources for different parts of Tillamook Bay as were established by surface sample analyses. They also indicate, however, that the sources of sediments at core sites downbay from the modern river deltas have changed with time. The general nature of this change has been (1) strictly local river and shoreline sources for older, basal sediments, (2) a mixed marine and river source for sediments of intermediate age in the middle of section, and (3) a return to a river source for younger near-surface sediments in the upper part of the bay. These changes suggest a transgressive-regressive sedimentation sequence in Tillamook Bay. During the transgressive phase, marine source sediments moved into Tillamook Bay, only to be overlain by river source sediments as the rate of transgression slowed, or the regressive phase began, and the rivers started to build deltas out into the bay.

#### Core Sample Stratigraphy

Stratigraphic data and interpretations for Tillamook Bay cores indicate that the deposits beneath the bay can be divided into an upper and lower unit. The upper unit is the Holocene or "modern"

fill in the bay, and its source and depositional history are the primary concerns of this effort. The lower unit in Tillamook Bay proper is divisible into (1) an upper intensely weathered gravel with relatively unweathered gravels, sands, and silts at depth, and (2) a lower moderately weathered but very hard, sand and silt with rare gravels. One or both of these possible divisions were penetrated at core sites 1, 3, 5, 10, 13, 14, 15, 16, 17, and 18-76. The best examples of the upper division are the 45.9 feet of weathered gravels at core site 18-76 and the 78.7+ of relatively unweathered gravels, sands, and peaty silts and clays at core site 13-76. Core sites 5 and 14-76 contain the best examples of lower division materials beneath Tillamook Bay. In the Miami River valley, basalts and interbedded clays underlie upper unit deposits, and are lower division materials.

The depth to the boundary between upper and lower units is shown on Figure VI-1, Sample Locations and Data. This boundary is very sharply defined in 11 of 17 cores by a change in drilling characteristics and or stratigraphy (Tables 11-27); the deposits below the boundary are frequently badly weathered (oxidized) at the surface, but still are usually more difficult to penetrate than are sediments of the upper unit.

The thickness of the upper unit varies from about 3.2 feet to greater than 104.9 feet (Map Figure VI-1). The unit is thin along the Eastern Margin of the bay north of the modern Tillamook-Trask-Wilson - Kilchis River delta where only 3.28 to 13.1 feet (1, 15, and 14-76) are present. The Central Bay west and north of Sandstone Point is underlain by a ridge of the lower unit, so that only 13.1 to 26.2 feet of the upper unit are present. Upper unit thicknesses in excess of 104.9 feet are observed in the modern major river deltas (4-76 in the Miami delta; 7, 8, and 9-76 in the Tillamook-Trask-Wilson-Kilchis delta) and toward the Western Margin (11 and 12-76) of the bay. In contrast, only 39.3 feet are present at core site 2-76 along the margin of the Miami River valley above the modern delta.

The stratigraphy of the upper unit is strongly depth dependent. The texture generally is "fine-grained", relative to that of the lower unit, with all samples analyzed averaging about 60 percent sand and 40 percent silt plus clay. Where the unit is thick in the modern river deltas, basal samples may show brown, gravel-size materials, and drilling data may indicate the presence of cobble and/or boulder size materials. Similar size materials are not present, however, in deep samples from core sites along the Western Margin of the bay.

Basal, coarse sediments are overlain by a 13.1 to 47.6 foot thick sequence of chiefly well stratified, silt and clay with only minor amounts of sand. These sediments may form the basal part of the upper unit where the unit is thin or, more commonly they overlie a thin unit that includes a mixture of silt and clay, some sand, and even fine gravels. Toward the Western Margin of the bay, the middle finer unit is not as well developed as in the delta regions, although the sediments there do become slightly finer at depth. In general, the top part of the upper unit is more sandy and less well stratified than the middle part almost regardless of the core site location.

The upper unit is characterized by abundant organic materials. These materials are chiefly isolated wood clasts or woody to fibrous and very fine organic layers. Their occurrence indicates that they are all detrital in origin. There also are occasional shell layers or zones that are mostly toward the lower part of the unit at core sites where the unit is thin. In general, organic materials, particularly woody materials, are more abundant in the delta regions than in core sites toward the Western Margin of the bay.

#### Core Sample Age

The results of age determinations by the radiocarbon technique are shown in Table VII-22 and are plotted in Figure VII-2. All samples analyzed for age were wood fragments or fibrous to fine woody organic materials that are detrital in origin. The data show that the sedimentary fill beneath Tillamook Bay consists of materials older than about 38,000 years before present (B.P.) and younger than about 8,400±400 years B.P. Stratigraphic data indicate that the older samples came from the lower unit, whereas the younger dates came from samples of the upper or "modern" fill in Tillamook Bay.

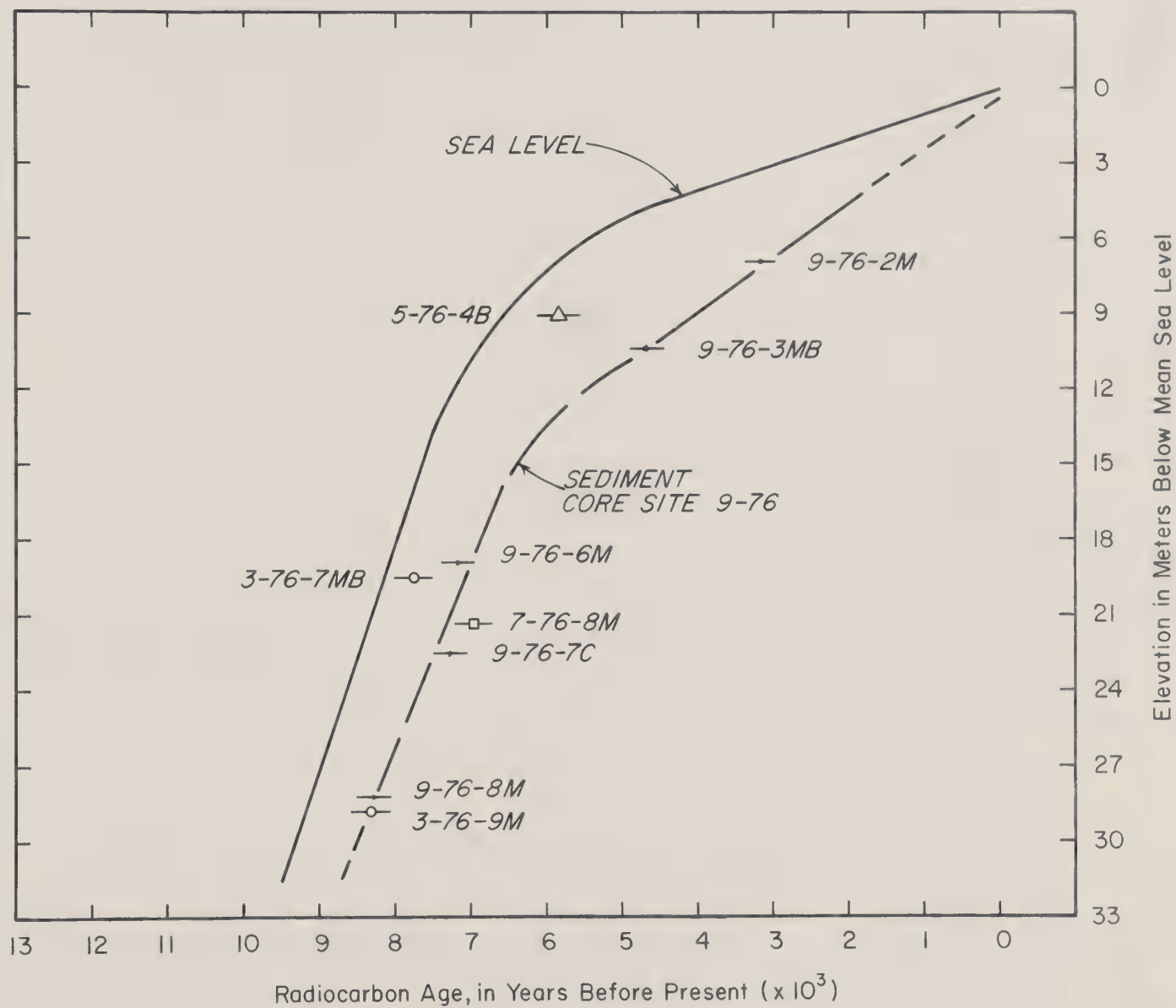
The modern fill in Tillamook Bay in the deep parts of the modern river deltas began to accumulate shortly before about 8,000 years B.P. In the Miami River delta (core site 3-76), a linear extrapolation of age-depth data to the base of the fill suggests that deposition there began between about 8,600 and 9,200 years B.P. At core site 5-76, also in the Miami River delta, the base of the modern fill is only about 36.3 feet below the sediment surface (about 39.6 feet below MSL), and the age of the basal materials is probably only about 6,500 to 7,000 years B.P. The base of the modern fill in the combined Tillamook-Trask-Wilson-Kilchis delta (9-76) was not defined by drilling data (Table 18), but is probably not far from the termination of drilling at about 105.9 feet (MSL); thus, the age of the basal part of the modern fill at this delta core site also should not be more than about 9,000 years B.P.

Table VII-22 RADIOCARBON AGE DETERMINATION OF SELECTED SEGMENTS FROM  
TILLAMOOK BAY ESTUARY SEDIMENT CORES

Field Sample Number	USGS Laboratory Number	$^{14}\text{C}$ Age* (Years B.P.)	Approximate Depth Below Sediment Surface (Feet)
3-76-7MB	W-3796	7,850 $\pm$ 300	60.6
3-76-9M	W-3795	8,310 $\pm$ 300	91.5
5-76-4B	W-3651	6,360 $\pm$ 300	26.5
5-76-6M	W-3660	>40,000	66.6
7-76-8M	W-3810	6,970 $\pm$ 250	66.6
9-76-2M	W-3658	3,300 $\pm$ 200	21.6
9-76-3MB	W-3729	5,190 $\pm$ 300	36.4
9-76-6M	W-3668	7,230 $\pm$ 350	61.3
9-76-7C	W-3654	7,450 $\pm$ 400	76.4
9-76-8M	W-3669	8,400 $\pm$ 400	91.5
13-76-3M	W-3645	>40,000	20.0
13-76-5C	W-3643	>38,000	36.7
13-76-7C	W-3642	>40,000	55.1

\* Analyses were done in the Radiocarbon Laboratory of the U.S. Geological Survey, Reston, Virginia. The  $^{14}\text{C}$  dates are based on the Libby half-life (5570 years) and are referenced to the year A.D. 1950. The error stated, always larger than the standard one-sigma statistical counting error commonly used, takes into account variable laboratory factors but does not include external variations or fractionation (field or atmospheric). The data have not been corrected for fractionation by a  $^{13}\text{C}$  measurement nor have they been converted to a calendar date by use of a tree ring curve.

Figure VII-2 Generalized world-wide sea level rise curve (from Kraft, 1971) and Tillamook Bay sediment disposition curve.



The minimum and maximum deposition rates were computed assuming the maximum and minimum age differences, respectively, between horizons; the "average" computation assumes that the age difference is equal to the measured value(s) without considering the possible stated error. The computed "deposition rates" do not take into account possible compaction or geometry changes, which are believed to be minimal but which are not readily determinable with the available data. In general, the apparent "deposition rates" indicate rapid disposition up to 6,000 to 7,000 years B.P., and slower rates since that time. The data suggest the possibility of different rates in the northern bay (Miami delta) than in the southern bay (Tillamook-Trask-Wilson-Kilchis delta). There is little evidence to establish a change in deposition rate in either delta in historical time; the rate at core site 9-76 between about 3300 and 5200 years B.P. is basically the same as the rate between the present and about 3300 years B.P.

### Core Sample Stratigraphy and Age

Stratigraphic and radiocarbon data indicate that Tillamook Bay, prior to the deposition of the modern fill, consisted of southern and northern deep river valleys separated by a ridge extending northwestward from about Sandstone Point. The deposits beneath the ridge and flanking the river valleys included materials that are interpreted as being Oligocene to Miocene sedimentary bedrock similar to that cropping out along the nearby bay margins. In some places, the bedrock is overlain by an older fill of weathered and unweathered fluvial gravels and interbedded lucastrine, peaty deposits that are Pleistocene (greater than 38,000 years B.P.) in age. Similar deposits have been described by Frye (1976, pp. 57-72) and have been found underlying terraces between Tillamook and Idaville, Oregon.

The modern fill in Tillamook Bay began to accumulate sometime prior to about 9,000 years ago when the gravels and sands of the river valley deposits rather abruptly changed to the silts, clays, and sands that characterize the modern of Holocene fill. In general, the deposition and characteristics of the Holocene fill apparently are related to the world-wide Holocene rise in ocean level. During the early rapid rise period, from about 7,000 to greater than 9,000 years B.P., the deposition was rapid and the deposits in much of the present estuary are well-stratified silts and clays. These characteristics suggest possible deep water deposition at rates sufficiently rapid to prevent much winnowing or disturbance by burrowing organisms. The relatively rapid deposition rate during this period might be a reflection of the geometry of the depositional embayment, the rate of sediment supply, the source(s) of sediments, or an increase (over the present) in the sediment "trap efficiency" of the early Tillamook estuary. Relative to sediment sources, compositional data begin to indicate initial contributions from the marine source during this period of relatively rapid ocean level rise. When the rate of ocean level rise began to decrease about 6,000 years

B.P., the rate of sediment deposition also decreased and the sediments generally are coarser and not as well stratified. Presumably these sediment characteristics reflect more winnowing and more time for organisms to "homogenize" the sediments. Sometime between about 3,000 and 5,000 years B.P., the ridge between southern and northern parts of Tillamook Bay should have begun to develop its present configuration. At the present time, sediments from the river source are accumulating in the river deltas and are prograding into the bay over sediments from the marine source. The vertical rate of accumulation of these sediments seems to be about the same from the present to 3,300 years B.P. as it was from 3,300 to 5,200 years B.P.

### Mineralogy of the River System

The major rivers emptying into the bay include the Miami, Kilchis, Wilson, Trask, Killam, and the Tillamook. The rivers for the most part originate in tuffaceous marine sedimentary rocks, intrusive rocks, and the Tillamook and Nestucca Formations.

The Miami River sediments range in volcanic glass content from 15 to 81 percent. The sediments from Illingsworth Creek are lowest with 15 percent, those from the Minich Creek are next with 29 percent, and those near the main channel of the Miami River are highest with 81 percent. These data fit the geologic formations which serve as source areas for the sediments. Illingsworth and Minich Creeks are mostly confined to the weathered sediments of the terraces and uplands in the lower part of the Miami River Valley. These sediments were derived from weathered basalt or sediments derived from basalt. They contain important amounts of pyroxene and iron oxides, but very little quartz. The sediments in the Miami River bank are mostly volcanic glass with minor amounts of feldspar and pyroxene. Neither the fine sand nor the very fine sands contain any quartz.

The sediments near the mouth of the Miami River near Hobsonville appear to have been derived from weathered basaltic area also. In the bay near the main channel to the north of the bay bar the sediments are relatively high in quartz, but may have been derived in part from sediments transported by off-shore ocean currents.

The Kilchis River sediments range in glass content from 38 to 88 percent. None of these sediments contain significant amounts of quartz either. Sediments in the Mapes Creek bank are only 38 percent glass, but the sands contain no quartz suggesting they came from weathered basalt. Again, the main channel of the river is very high in volcanic glass. The upper part of the Kilchis River is entirely in the Tillamook volcanic series. Bay sediments at the mouth of the Kilchis River are high in volcanic glass as one would expect considering the source area for the Kilchis River.

The Wilson River sediments range in volcanic glass content from 42-55 percent. Iron oxides such as hematite and magnetite are also important components. Only a percent or two of quartz was found. The source area includes the Tillamook volcanic series (mostly basalt), the Nestucca volcanic series (dark-grey tuffaceous shale and siltstone and thin-bedded sandstone with interbedded basalt and andesite), and smaller areas of mafic intrusive rocks (gabbro, diorite, and diabase).

The Trask River is another large potential sediment contributor. Its sediment seems a little lower in glass than does the Wilson River. Pyroxene is a major component of these sediments. The sediment source seems to be the same as that of the Wilson River.

The Tillamook River has one tributary, Killam Creek, which flows through the Tillamook volcanic series (basalt), but for the most part its sediments are derived from sedimentary rocks (massive, micaceous sandstones, tuffaceous and micaceous sandstone, tuffaceous siltstone, and mudstone). Its glass content is also high and quartz content low.

## CHAPTER VIII

### OTHER ENVIRONMENTAL PROBLEMS



# OTHER ENVIRONMENTAL PROBLEMS

## IMPACTS OF SEDIMENT ON FISHERIES

There have been many studies elsewhere on the Oregon coast of the impacts of sediment on fisheries and the production of sediment by road building, logging, and slash burning activities. Much of that data has been used in the Tillamook basin.

There are three recognized kinds of direct effects which sediment may have on fish. Sediment may suffocate the eggs, thus preventing hatching. Sediment may seal the surface gravels and prevent the fry from emerging. Sediment may also cause physical damage to the surviving fish, interrupting normal development, maturing, and spawning processes.

Examination and observation of salmonids subjected to various sediment concentrations have led researchers to believe that the behavior of the fish can also be disrupted. Fish have been observed to become erratic in their movements after being subjected to heavy sediment loads but apparently suffered no physical damage.

Aquatic insects and small crustaceans which form important segments in the food chain can be used to measure the health of a watershed. The eggs and various larval stages prior to achieving maturity are subject to damage by sediment. A significant reduction of eggs decreases the carrying capacity of a stream as a rearing or growing area. Streams of a deteriorating watershed will have fewer of the desirable insects and crustaceans such as the odonates (damselfly) and amphipods, while the less desirable insects and crustaceans, such as the dipteras and annelids, will increase.

No literature was found to support the foregoing in the Tillamook basin. However, sampling and measurement of sediment in Tillamook stream systems and the bay sediments indicate very high sediment loads.

Historical records of fish caught in the streams and estuary indicate a definite decline in numbers available. While there may be other factors contributing to this reduction, the most significant one noted has been that of the heavy sediment loads. A strong correlation is evident between the increase in sediment yield from Tillamook Bay tributaries and the decline of chum salmon. Catch and escapement records show the average 10-year catch took a 63 percent drop from the 1937-46 catch to the 1947-56 catch and a 78 percent drop from there to the 1957 to 1962 period. Commercial fishing was discontinued on chum salmon in 1962.

## IMPACT OF SEDIMENT ON RECREATION

Tillamook Bay is Oregon's second largest estuary, yet the bay is not as busy nor as popular as others such as Winchester Bay. Sediment has filled the bay over the years until today 75 percent of the area is less than five feet deep during high tides. The shallow areas can be a hazard to the inexperienced visitor. Many unsuspecting boat operators are trapped on the mud flats when the waters recede with the change in tide. There is very little time from the start of the water recession until the mud flats are exposed.

The tideflats of Tillamook Bay are quite extensive with much debris, rotting vegetation, and other organic matter exposed at low tide. The odor emitted can be very unpleasant.

## ANIMAL WASTE

Tillamook drainage basin pastures are among the most productive in the County. Nearly all of the cattle are dairy stock. The very style of operation tends to concentrate the cows even when they are on pastures. The normal practice is to set up the lands of the dairy in 40 or 80-acre pasture units and to keep the cows, often as many as 200, together on the same pasture and rotate the pasture use as needed. The cows are even more concentrated twice a day when they are milked.

The effluent resulting from these periods of concentration and from cleaning the barns causes a serious problem. Rainfall intensities are such that storage and disposal is costly and complicated. Disposal has been partially resolved. The effluent from several dairies is now being collected and stored in liquid form in concrete tanks during the rain periods. The liquid slurry is then sprayed on the pastures during the dry months, thus irrigating and fertilizing them at the same time.

The effluent from farms without tanks tends to wash and drain into the stream systems, contributing to the total pollution problem of the bay. The high nutrient and bacteria content of the effluent encourages undesirable vegetative and animal propagation and contributes to the odor problem of the bay.

## AIR POLLUTION

Slash burning of clearcuts is not nearly the problem today that it was prior to passage of the Federal Environmental Quality Act. All clearcuts had been burned as part of the accepted timber harvesting program.

Substantial volumes of residue from logging operations and from natural processes in the forest environment are still burned each year as a forest management practice. The burning aids in reforestation of the site, reduces the chances of wildfires, and helps to control pests without use of chemicals.

Most slash burning takes place in the fall after the first rains. The impact of slash fires on air quality is of concern in the basin because of the restricted ventilation conditions and the type of forest areas located there. The older timber stands are highly defective, and much of the cull and rotten material cannot be economically utilized. Thus, residue volumes averaging 120 tons per acre often remain following harvesting operations.

Several forces are involved in reducing the amount of slash burning and in rendering the practice less harmful. A regulatory program now provides for restricted areas and the issuance of burning permits. Another smoke management plan on a voluntary basis calls for timing the burning operations with most favorable meteorological conditions. The Department of Environmental Quality, along with public and private timber owners, is involved in this cooperative effort. Other factors that have contributed toward a reduction in slash burning have been (1) an improved technology that leads to increased utilization of certain materials which formerly were left in the forest as debris after harvesting operation, (2) clean logging or complete yarding of residue that either makes burning unnecessary or permits off-season burning, (3) a gradual replacement of old-growth timber by second-growth stands and substitution of partial cutting for clear cutting, (4) pressure brought about by passage of the Federal Environmental Quality Act and an executive order from the Office of the President which permits federal agencies to engage in polluting practices only as a last resort.

Old-growth or other timber stands will have substantial debris that will not be salvageable. At the present rate of cutting, old-growth stands in the basin will be completely harvested by year 2020.



## CHAPTER IX

### LAND TREATMENT ALTERNATIVES



# LAND TREATMENT ALTERNATIVES

## EXISTING MEASURES AND PROGRAMS

Tillamook Bay drainage basin has a long history of flooding, erosion, and sediment problems. The problems are triggered by major storm events such as occurred in 1964, 1972, and 1977. The impacts of these events can be greatly reduced by a well-planned program of resource improvement, protection and use.

The on-going programs have accomplished much in protection and correction. These may not always have been the most economical or efficient methods available. This section will explore the current programs and relate them to the needs for accelerating the efforts to further reduce sediment delivery into the estuary.

### AGRICULTURAL LANDS

Present land treatment measures related to control of sheet and rill erosion, streambank erosion, and sediment deposition on agricultural lands are relatively limited in the agricultural area. Installation of rock riprap on the channel banks has been the principal treatment measure, with some being placed under the Emergency Watershed Protection Program (Section 216 of Public Law 81-516) and the remainder placed at the expense of the local landowner. As of 1977, a total of 69,434 lineal feet of riprap has been installed. Observations indicate that it is probably the most effective means for treating streambank erosion.

Restoration of dikes in the lower flat areas of some drainages has been accomplished by rebuilding the dikes and protecting them with riprap materials. Since these areas are affected by both stream-flow and tidal action, such treatment has materially reduced the erosion hazard. Repair work has been done by individual landowners or under the Emergency Watershed Protection Program. Approximately 2,397 lineal feet of this type of protection has currently been completed on the lower reaches of the Miami, Kilchis, and Trask Rivers.

Reseeding of streambanks and other small areas of eroded farmland has been done on an intermittent basis--usually following periods of high water and/or overbank flooding conditions. Much of this type of treatment has been voluntary but some has been financed under the previously mentioned emergency program. Tree removal from the channel banks has been minimal, as well as removal of debris from the channels. Those temporary remedial measures are usually financed by the local landowner.

## FOREST LANDS

Twelve million dollars were expended on forest lands in the basin over a 24-year period to reforest the Tillamook Burn. It proved to be one of the most ambitious reforestation and fire protection efforts ever undertaken in this country. Reduction of soil loss was an objective of this effort, but not the primary one. If erosion control and sediment reduction had been the primary objective, another twelve million would have been needed and the restoration period reduced to maybe 2 to 5 years.

The fires had left a total of about 355,000 acres devoid of vegetation and destroyed most of the natural regeneration and early reforestation efforts. The five basins were contributing massive loads of sediment to the stream systems. The reforestation program, under the direction of the State Forester, was started in 1949 and culminated in 1973 with the successful planting and seeding of 217,800 acres and intensified fire protection of the entire watershed. Tillamook drainage basin portion of the "Burn" was estimated to be 228,600 acres with about 194,700 acres reforested.

A resource management plan is being developed to provide for the best management of this forest for the future. The State Forest Practices Act applies to all forested lands in the basin and will provide much of the direction taken in administration of these resources. This Act was passed by the State of Oregon in 1972 to maintain forest tree species, soil, air and water resources, and fish and wildlife habitat of the forests of Oregon. The various sections of the Act provide minimum practices and set limitations upon forest land managers to attain these ends.

Forest landowners of the basin have included in their timber harvest plans various erosion control programs to coincide with timber harvest. These include stabilization of soils on 163 miles of temporary roads, grass seeding of 3,138 acres to prevent sheet erosion, stabilizing 374 earth slumps and slides, and surfacing of 918 miles of permanent roads to control surface erosion. These are displayed by planning periods on Table IX-1. These measures are planned as part of future harvesting programs for each of those periods. The backlog of needs to control erosion and sediment resulting from the fires and past resource uses will still remain. An accelerated program is necessary if the impact of old problems is to be reduced.

Table IX-1 Erosion Control Work Planned--Forest Lands

Type of Work	1975- 1980	1981- 1990	1991- 2000
Temp. Roads & Spurs To be put to bed (miles)	21	62.5	79.5
Grass & Legume Seedings (acres)	786	1,599	753
Stumps & Slides to be Stabilized (ea.)	78	141	155
Roads Surfaced to Control Soil losses (miles)	146	404	368

TILLAMOOK BAY

The U.S. Corps of Engineers has given the Tillamook Bay considerable attention since 1912 when authorization was received to construct the north jetty. Construction was started in 1914 and finished in 1918 to a length of 5,400 feet. The jetty was repaired and extended to 6,000 feet in 1931-33 and has been rehabilitated twice; once in 1953 and again in 1965. The south jetty was authorized in 1965 and construction was underway in 1969, resulting in a 6,000-foot jetty. Consideration has been given to extending the south jetty to 8,500 feet.

A breach of Bayocean Peninsula occurred in 1952. The breach was repaired by constructing a concrete dike and filling in behind it with dredged material from the bay. Construction of the south jetty has led to increased marine source deposition of sand and an increase in width of the spit. It also has, to some extent, countered the affect of the north jetty. Erosion has been reduced behind both jetties and deposition increased between the jetties.

The bar continues to present a problem. Sand is trapped between the jetties and there has been an apparent increase of inner channel sediment deposition in recent years. Shoaling of the bar has all but closed access to the bay during low tide.

Dredging in the basin began in 1922 with the initial effort directed to maintaining the port at Bayocean. This effort proved futile and was abandoned about 1930 in favor of the Miami Cove port and boat basin. Dredging from that time on was carried out on the bar, in the channel to Garibaldi, and in the Miami Cove boat basin.

In 1927 a great deal of effort and dollars was expended to create the boat basin at Miami Cove. Since that time, there has been a decrease in effort. The dollars spent per year for the period 1922 through 1929 averaged about \$28,100. Expenditures dropped to about \$11,500 during 1930-39 and held near this level until 1970-76 at which time it climbed back to \$25,800. This was due to an all out effort in 1976 when \$180,300 was spent. (See Figure IX-1 and Figure IX-2).

Accomplishments have had a steady decline, as noted on Figure IX-1 and IX-2 since the beginning of operations. In effect, dredging operations have been losing ground due to increased costs, increase in bay and bar sediments, and the lack of new dollars to do an adequate job.

#### OTHER LANDS

Land treatment measures on urban acreage is limited to seedings and tree plantings around industrial plants. Tillamook County has done some critical area seeding in areas such as the county dump. The erosion and sediment control measures applied to private farm home and building areas include planting lawns and/or various types of landscaping on areas subject to erosion.

Figure IX-1 U.S. Corps of Engineers Dredging of Tillamook Bay 1922-1976

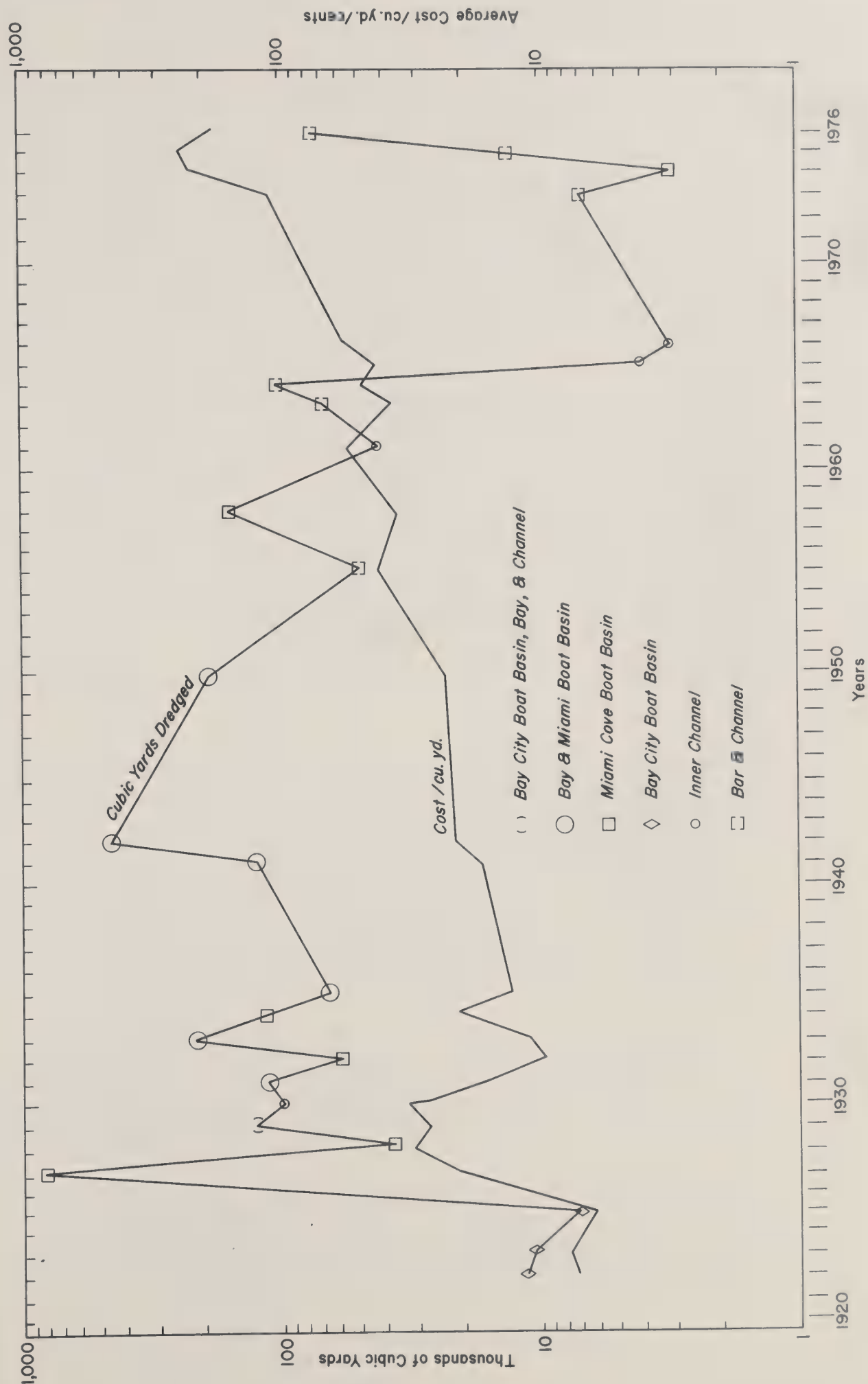
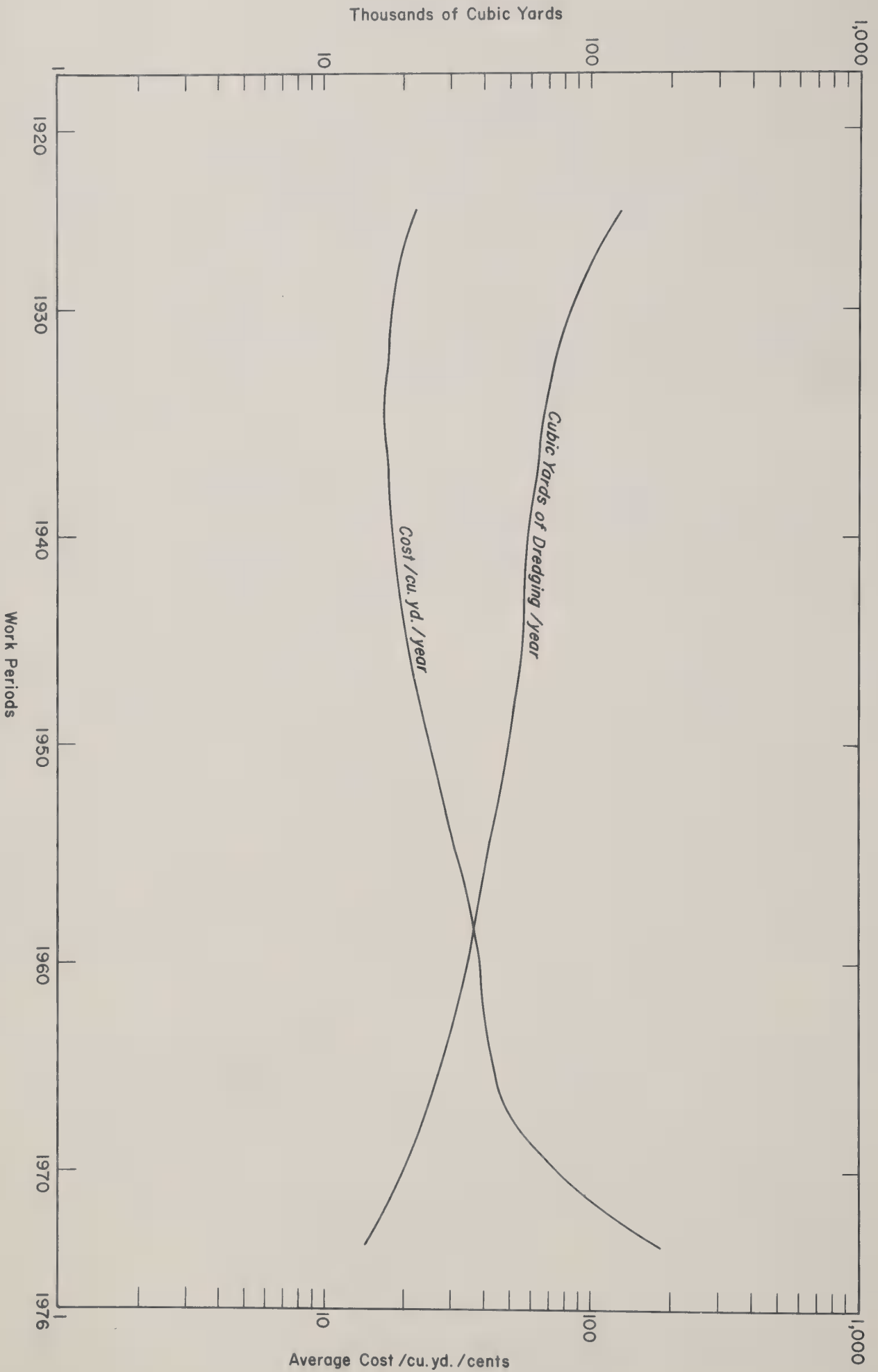


Figure IX-2 Periodic Means of U.S. Corps of Engineers Dredging.



# ALTERNATIVES TO ACCELERATE LAND TREATMENT

## AGRICULTURAL LANDS

With an over-all cropping pattern of largely irrigated and dryland pasture, any reduction in sediment yield is limited to re-establishment of older or eroded areas of pastureland. This would also apply to areas of brush-pasture although there would be variable benefits through protection by access trails, deferred grazing, and electric fence installations.<sup>1/</sup> In small isolated areas of pasture-timber, fencing and/or deferred grazing should also permit a small reduction in sediment yield.

Although the estimated acres subjected to flood scour are small, there are a number of possible alternatives which will result in erosion and sediment yield reductions. On cropland, the primary treatment is plowing, seeding, fertilizing and irrigating of affected areas, with added benefits from electric fencing and deferred grazing. Scouring on gently sloping streambank areas can be minimized through application of pit run gravel on cattle access areas. Similar improvement and reduction in sediment yield can be made on the steeper bank areas which are subject to surface runoff by placement of riprap, back sloping and revegetation, or removal of any debris from the area.

Alternatives to reduction of roadside erosion are seeding, mulching and fertilizing the area affected.

The placement of riprap on critically eroding streambank areas was considered to be a possible solution to reduce erosion and sediment yield caused by bankcutting. Backsloping and revegetation measures on both critical and non-critical banks would provide limited protection although it probably would require annual maintenance and would take more land out of production. An alternative measure to reduce erosion on cattle trails into the river bottom would be the application of pit run gravel on the area affected to firm up the trail and also to provide better drainage. Another logical alternative would be to install an electric fence around the areas, thus excluding it from all use.

Removal of streambottom debris is one practical sediment treatment measure to control streambottom scour. In some cases commercial operations for removal of gravels (except Tillamook River) can be expected to have a limited effect on the quantity of sediment available for transport to Tillamook Bay.

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<sup>1/</sup> Electric fencing, a temporary measure to keep cattle away from erosion problem areas, is actually just another category of deferred grazing. Electric fencing is considered temporary, or "stop-gap", since it could be moved and quickly reinstalled where needed.

A total of 13 viable land treatment measures to reduce erosion and sediment yield in the agricultural area were selected for analysis from a list of known treatment measures. These varied in initial cost from \$6.00 per acre for portable electric fencing to \$39,200.90 per acre for installing rock riprap. The thirteen selected measures and costs are shown on table IX-2.

These alternatives, their costs, and effects on erosion and sediment rates have been analyzed using a least-cost erosion and sediment model, discussed later in this chapter.

Several levels of sediment reduction have been proposed in this study along with the resulting alternatives to reach these levels. Alternative measures not included in this analysis were considered as not being cost-effective at this time.

### FOREST LANDS

Erosion and sediment delivery rates on forest lands in the basin are among the highest for any forest lands in the State. The average annual sediment yield today is about 20 times that which probably occurred prior to 1875. However, the average sediment rate today is only about 12.5 percent of the extremely high rate that very likely occurred between 1939 and 1945 as a result of wildfires and salvage logging.

The reduction in the sediment delivery rate from forest lands since 1945 could not have occurred naturally in this time period. The repetitive fires, expansive areas covered by the fires, and the severity of the burns left the soils totally bare over most of the 228,600 acres burned in the basin. Concerned citizens and the land management skills of the staff of the State Forester led to one of the largest reforestation and resource protection efforts ever launched in this country. A total of about 194,700 acres of the basin portion of the "Burn" were successfully reforested by 1973. The resulting reduction of erosion and sediment rates was an objective of this effort, in addition to putting the lands back into production.

Erosion and sediment rates on forest lands still make significant contributions to the problems of the basin. The mean annual gross erosion amounts to 286,245 tons. The mean annual fluvial sediment load is 51,602.6 tons from forest lands. These are 95.6 percent and 85.1 percent, respectively, of the basin totals.

Any further reduction of the sediment load caused by the existing problems will require an accelerated program. Eighteen feasible alternative land treatment measures were selected for analysis from a list of known treatment measures. These varied in initial cost from \$70.00

Table IX-2 - Amortization of costs of sediment control measures, agricultural lands, Tillamook Bay Drainage Basin, 1975

Control Measure	Initial cost	Expected duration	Average annual cost 1/	Annual Maintenance cost	Total average annual cost
	Dollars per acre	Years	-----Dollars per acre per year-----		
Seed grass.....	100.00	5	24.15	0	24.15
Seed & mulch grass.....	150.00	5	36.22	0	36.22
Seed, mulch, & fert. grass.....	250.00	5	60.36	0	60.36
Plow, seed, & fert. grass.....	300.00	8	49.51	0	49.51
Plow, seed, fert. & irr. grass..	400.00	8	66.02	0	66.02
Backslope & revegetate.....	6,530.00	15	700.07	57.35	757.42
Remove stream debris.....	150.00	1	159.94	0	159.94
Rock pit run.....	3,200.00	10	447.74	96.00	543.74
Rock riprap.....	39,200.00	30	3,040.83	392.00	3,432.83
Portable electric fence.....	6.00	1	6.40	0	6.40
Deferred grazing.....	50.00	1	53.31	0	53.31
Access trails.....	11,912.00	10	1,666.72	96.00	1,762.72
Gravel removal.....	0				0

1/ The average annual cost was calculated using the current interest rate in Federal Water Resource projects set by the Water Resources Council (6 5/8%).

SOURCE: Based on information provided by the Soil Conservation Service, Portland, Oregon.

per acre to seed trees (1975 cost basis) to \$20,000 per acre for seed, mulch, fertilize and rock buttress. The eighteen selected measures and costs are shown on Table IX-3.

These alternatives, their costs, and effects on reduction of erosion and sediment rates have been analyzed using a least-cost erosion and sediment model, discussed later in this chapter.

The data accumulated for each of the eleven sub-watersheds was examined individually and as a whole. Several levels of sediment reduction have been proposed in the model along with the resulting alternatives to reach these levels. Alternative measures not included in this analysis were considered as not being costeffective at this time.

Table IX-3 Amortization of costs of sediment control measures, forest lands, Tillamook Bay Drainage Basin, 1975

Control Measures	Initial cost	Total average annual cost <u>1/</u>
	Dollars per acre	Dollars per acre per year
Seed grass.....	150	9.95
Seed & fertilize grass.....	300	19.91
Seed, fert., mulch, & net grass.....	600	39.82
Seed, mulch, terrace & fert. grass..	2,100	139.35
Plant brush on streamsides.....	520	34.51
Plant brush on landslides.....	800	53.09
Plant trees.....	300	19.91
Seed trees.....	70	4.65
Plant trees, grass, & fert.....	600	39.82
Water bar & vegetate.....	1,750	116.13
Gravel road surface.....	5,500	364.97
Stabilize & close roads.....	2,200	145.99
Gravel road surface & hydromulch....	5,800	384.88
Seed, mulch, fert., & rock buttress.	20,000	1,327.17
Rock riprap.....	15,000	995.38
Backslope & plant brush.....	1,500	99.54
Check dams.....	8,000	530.87
Debris & log jam removal.....	10,000	663.59

1/ The average annual cost was calculated using the current interest rate in Federal Water Resource projects set by the Water Resources Council (6 5/8 percent at 100 years).

SOURCE: Based on information provided by the Forest Service, Portland, Oregon.

## TILLAMOOK BAY

Some resource uses of Tillamook Bay have been greatly reduced by the erosion and sediment problems of the basin. Funds available for dredging have not been sufficient to maintain a clear bar and an open channel to the various boat basins and docks. Economic losses have occurred to fisheries and shell fisheries. Portions of the bay have been filled by sediments to the point that these areas are now above high water line. These areas now provide a mesic type pasture or have been further filled and developed for industrial uses. A total of 102.63 acres of tidelands had been filled in by 1972, and put to other uses. This particular treatment of the tidelands has been largely curtailed. Land ownership patterns restrict further fill and development as do county plans and coastal zone management planning for Tillamook Bay.

Reduction of the erosion and sediment rates occurring from land and stream sources is not the total solution to sediment problems in the bay. Following are several examples of alternatives which could be considered to possibly alleviate the present sediment load already in the bay system. These alternatives would require additional study to determine technical and environmental feasibility and economic justification.

1. Construction of a floodgate and channel to the ocean at the upper end of the bay. The floodgate could then be opened and closed alternately with the tides and flood events to change the flow pattern of the bay and to provide a surge-flush action on the upper bay sediments.
2. Increase funds for a one to five year period and dredge the bay and channels to a desirable depth. This would be successful only after the watershed is well stabilized.
3. Do nothing and allow the estuary to continue to fill with sediment and convert to new uses such as additional pasture.
4. Accelerate sedimentation in selected portions of the bay by a series of dikes and dredge-fill operations. This would result in a smaller, deeper bay.

All of the alternatives will be disruptive to the estuarine ecosystem. This system has already had much disruption and will continue to deteriorate even if nothing (alternative 3) is done. The primary objective of this study was to suggest alternative measures to reduce the sediment loads coming into the estuary. Once sediment is reduced to acceptable levels, consideration can be given to the complex question of what must be done with in-bay sediments.

Some questions that must be answered are:

1. If the sediment load from the watershed is reduced to an acceptable level, what minimum depth tide is desirable throughout the bay?
2. Is the public willing to accept short term (3-5 year) interruption of the existing ecosystems to allow overall dredging?
3. How much channel is needed to what ports or boat basins, and when should these be accessible--high tide or low tide? There will no doubt be many other questions requiring answers.

Above all, both economic and environmental justification will be necessary for all decisions made as a result of this study.

#### OTHER LANDS

Any further reduction in erosion and sediment production should include increased application of erosion control measures on industrial, city and county areas. Additional treatment measures could also be projected to cover privately owned areas containing homes and farm buildings.

## ANALYSIS OF ALTERNATIVE TREATMENT MEASURES

### ANALYTICAL PROCEDURES

The major objective of this study was to propose methods of reducing sediment entering Tillamook Bay. A corollary objective was to insure sediment reduction at least cost.

Erosion and sediment control measures, costs, tons per acre, and acres were presented in preceding sections.<sup>1/</sup> Now it will be explained how the control measures and the associated sediment rates and costs were analyzed to determine least cost solution combinations.

Several alternative sediment reduction levels were examined.<sup>2/</sup> Analyses were conducted at 10 percent reduction intervals to the maximum possible reduction.<sup>3/</sup> Least cost combinations of control measures were obtained for sediment at each reduction level.

1/ Erosion and sediment control measures and costs are presented in this chapter, LAND TREATMENT ALTERNATIVES, ALTERNATIVES TO ACCELERATE LAND TREATMENT MEASURES. Existing (1975) erosion and sediment rates were also discussed in this chapter under EXISTING MEASURES AND PROGRAMS.

2/ At the time this analysis was conducted, no clear picture was evident as to how much sediment should be reduced. Data were not available to indicate how much of the sediment entering the bay is washed on out past the jetties into the ocean. In hopes that later in this study, or in subsequent studies, more information would be forthcoming on sediment depositions in the bay, it was decided to continue the analyses over the entire range of possible reductions.

3/ Analyses can be conducted for any desired feasible erosion or sediment reduction.

## THE MODEL

The technique used to conduct the analysis was linear programming. Linear programming basically involves finding an optimal solution to several equations, simultaneously, subject to specified constraints.<sup>1/</sup> For Tillamook, the equations represent relationships between erosion and sediment rates, costs, and acres for each of 11 forested and 5 agricultural sub-basins. Optimal solutions provide minimum or least-cost combinations of control measures. Constraints consist of acreages of erosion and sediment sources, and limits of total permissible erosion or sediment in tons per acre.

Several solutions were obtained at different constraint levels. The 1975 solution was used as a base or present situation. Erosion and sediment rates were then constrained to successively lower levels and least-cost solutions obtained at each constraint level. Finally, the maximum possible erosion or sediment reduction was determined with an associated control cost.

## DATA

Data for the sediment analyses were provided by the Soil Conservation Service and Forest Service. Data and data-gathering techniques have been explained earlier in this report. Tables IX-4 and IX-5 are examples of sediment data used in the model. Information shown on these tables - sources, rates, acres, and costs are explained next. Data tables for all 16 sub-basins are included in the Appendices.

<sup>1/</sup> Linear programming is a standard research tool and has been around for some time, at least since World War II when it was used for planning military operations. For additional information see: Scheurman, Lynn, REX Linear Programming System, Version 1, Oregon State University Computer Center, Revised May, 1972; and Dantzig, George B., Linear Programming and Extension, Princeton University Press, Princeton, New Jersey, 1963, 632 pages. Many other good references on linear programming are also available.

Due to the large number of mathematical calculations necessary to solve for optimal LP solutions, the modern, highspeed computer is a uniquely suited tool for this type of analysis.

Table IX-4 --Sediment rates of alternative control measures, agricultural lands, Wilson River, Tillamook Bay Drainage Basin, 1975

Sediment Source	1975 Sediment Rates	Control Measures										Acres				
		Seed Grass	Seed & Mulch Grass	Seed, Mulch, & Fertilize Grass	Plow, Seed, & Fertilize Grass	Plow, Seed, Fertilize, & Irrigate Grass	Backslope & Revegetate	Remove Stream Debris	Rock, Pit Run	Rock, Rip Rap	Portable Electric Fence		Deferred Grazing	Access Trails	Gravel Removal	
		Tons per acre per year														
Irrigated pasture.....	.0005	--	--	--	.0005	.0005	--	--	--	--	.0005	.0005	.0005	--	762.80	
Dryland pasture.....	.0463	--	--	--	.0442	.0260	--	--	--	--	.0442	.0416	.0442	--	2134.20	
Brush pasture.....	.0525	--	--	--	.0378	.0231	--	--	--	--	.0462	.0420	.0504	--	190.00	
Brush-hardwood.....	.0633	--	--	--	--	--	--	--	--	--	--	--	.0613	--	30.00	
Brush-Douglas Fir.....	.0246	--	--	--	--	--	--	--	--	--	.0246	.0246	.0246	--	110.00	
Pasture-Douglas Fir.....	.0552	--	--	--	--	--	--	--	--	--	.0528	.0480	.0552	--	250.00	
Douglas Fir.....	.0060	--	--	--	--	--	--	--	--	--	.0060	--	--	--	10.00	
First season tillage.....	.0240	--	--	--	.0216	.0072	--	--	--	--	.0072	--	--	--	357.20	
Urban lands.....	.0003	--	--	--	--	--	--	--	--	--	--	--	--	--	130.00	
Paved roads.....	.0020	.0015	.0014	.0011	--	--	--	--	--	--	.0017	--	--	--	71.20	
Gravel roads.....	.0730	.0498	.0397	.0381	--	--	--	--	--	--	.0663	--	--	--	31.50	
Channel erosion.....	28.9489	--	--	--	--	--	25.1321	26.2478	--	--	--	--	--	24.8385	17.03	
Channel erosion, critical....	1123.7113	--	--	--	--	--	932.9897	979.3814	--	.0000	--	--	--	969.0722	.19	
Channel bank cattle access...	166.2500	--	--	--	--	--	118.7500	--	.0438	--	85.0000	--	95.0000	--	.16	
Streambottom scour.....	156.7500	--	--	--	--	--	--	145.5000	--	--	--	--	--	97.0000	.40	
Streambottom debris.....	156.8571	--	--	--	--	--	--	145.5000	--	--	--	--	--	97.0000	7.00	
Flood plain scour.....	.1057	--	--	--	.0543	.0500	.0700	.0500	--	.0500	.0943	.0500	--	--	7.00	
Water.....	.0000	--	--	--	--	--	--	--	--	--	--	--	--	--	306.10	
Gravel operations.....	.5296	--	--	--	--	--	.3380	.3380	--	.0966	--	--	--	.2910	6.42	
Rip Rap.....	.0000	--	--	--	--	--	--	--	--	--	--	--	--	--	8.80	
TOTAL ACRES.....																4430.00
Dollars per acre																
Control cost per acre, 1975..																0

SOURCE: U.S. Department of Agriculture, Soil Conservation Service; Forest Service; Economics, Statistics, and Cooperatives Service; in cooperation with the Oregon Water Resources Department and the Tillamook Bay Task Force.

Table IX-5---. Sediment rates of alternative control measures, forested lands, Trask River-Main Stem, Tillamook Bay Drainage Basin, 1975.

Sediment source	Control measures															Area Acres				
	1975 sediment rates	Seed grass	Seed & fertilize grass	Seed, fert., mulch, & net grass	Seed, mulch, terrace, & fert. grass	Plant brush on streambeds	Plant brush on landslides	Plant trees	Seed trees	Plant trees, grass, & fertilize	Waterbar & vegetation	Gravel road surface	Stabilize & close roads	Gravel surface and hydromulch	Seed, mulch, fertilizer, and rock buttress		Rock riprap	Backslope & plant brush	Check dams	Debris & log jam removal
Brush & seedlings.....	.0280	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Saplings & poles.....	.0209	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mature second growth...	.0108	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hardwoods.....	.0030	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Old growth.....	.0008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Paved roads.....	.1500	.0636	.0311	.0130	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gravel two track.....	.2742	.1402	.0731	.0305	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Secondary 1 1/2 track...	.3192	.1573	.0972	.0694	--	--	--	--	--	--	--	.1041	--	.0416	--	--	--	--	--	--
Spur one track.....	.4200	.2129	.1183	.0710	--	--	--	--	--	--	.0591	.1331	.0177	.0444	--	--	--	--	--	--
Skid road 1/2 track...	.3300	.1608	.1100	.0677	--	--	--	--	--	--	.0592	.3216	.0203	.0338	--	--	--	--	--	--
Fire trails.....	.1050	--	--	--	--	--	--	--	--	--	.0095	--	--	--	--	--	--	--	--	--
Rail grade - in use....	--	--	--	--	--	--	--	--	--	--	.0030	--	--	--	--	--	--	--	--	--
Rail grade - abandoned.	.0060	--	.0009	--	--	--	--	--	--	--	.0109	--	--	--	--	--	--	--	--	--
Power line corridors...	.0480	--	.0281	--	--	--	--	--	--	--	.4857	--	.1844	--	--	--	--	--	--	--
Motor bike trails.....	.6660	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Landslides, upper 1/3..	2.0000	--	--	1.3793	.3678	--	1.0115	1.7931	--	.8276	--	--	--	--	--	--	--	--	--	--
Landslides, middle 1/3.	7.0000	--	--	3.9161	1.2238	--	3.4266	5.3846	--	2.2028	--	--	--	--	--	--	--	--	--	--
Landslides, lower 1/3..	6.3000	--	--	4.7386	2.1060	--	2.9836	4.7386	--	2.6326	--	--	--	--	.3510	--	--	--	--	--
Channel banks.....	.370	.1760	--	--	--	187.9355	--	--	--	--	--	--	--	--	--	37.5871	93.9678	--	--	--
Channel bottoms.....	96.0000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60.0000	42.0000	--
Flood plains.....	13.0000	--	--	--	--	4.1340	--	5.5120	--	--	--	--	--	--	--	--	--	--	8.2680	--
Clearcuts, >75% bare...	.9150	.3660	--	--	--	--	--	.7306	.8206	.1830	--	--	--	--	--	--	--	--	--	--
Clearcuts, 50-75% bare.	.5160	.2064	--	--	--	--	--	.4128	.4888	.1018	--	--	--	--	--	--	--	--	--	--
Clearcuts, 25-50% bare.	.2000	--	--	--	--	--	--	.1600	--	--	--	--	--	--	--	--	--	--	--	--
Clearcuts, 0-25% bare..	.0250	--	--	--	--	--	--	.0200	--	--	--	--	--	--	--	--	--	--	--	--
Burns, >75% bare.....	.8040	--	.5628	--	--	--	--	.6593	--	.2814	--	--	--	--	--	--	--	--	--	--
Burns, 50-75% bare....	.4500	--	.3150	--	--	--	--	.3750	--	.1125	--	--	--	--	--	--	--	--	--	--
Burns, 25-50% bare....	.2560	--	.1536	--	--	--	--	.1707	--	.0683	--	--	--	--	--	--	--	--	--	--
Burns, 0-25% bare.....	.1680	--	.1596	--	--	--	--	.1260	--	.0420	--	--	--	--	--	--	--	--	--	--
Streams, >10' wide....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sand beach.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rock.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL ACRES.....																				860
																				69,920
Control cost per acre, 1975.....		150	300	600	2100	520	800	300	70	600	1750	5500	2200	5800	20,000	15,000	1500	8000		10,000

SOURCE: U.S. Department of Agriculture, Soil Conservation Service; Forest Service; Economics, Statistics, and Cooperatives Service -- in cooperation with the Oregon Water Resources Department and the Tillamook Bay Task Force.

## SEDIMENT SOURCES

Criteria for selection of sediment sources was explained earlier. Basically, sediment source areas imply a recognition of readily distinguishable categories of known sediment problems. Sources were delineated in such a way so as to be adaptable to specific data-gathering techniques. Various categories of source acres always sum to the sub-basin total acreage. Thus, total acreage for any given sub-basin is always accounted for, even acreages with no problems; i.e., water, rock, etc.

## CONTROL MEASURES

Thirty-one control measures, or combinations of control measures, were picked as being applicable to the Tillamook Basin. These 31 were gleaned from a much larger list. Most of the measures not chosen were judged to be ineffective or unreasonably costly. Sediment rates were estimated for control measures, based primarily on expert knowledge of the effectiveness of these measures in the Tillamook Bay Drainage and in other areas.

## EROSION RATES

Techniques used to obtain erosion rates per acre are explained earlier in this report. In summary, the Universal Soil Loss Equation System (USLE) was used for crop and pasture lands in the agricultural areas. Channel bank erosion on agricultural lands was estimated from comparative aerial photo analyses where differences in bank cutting were calculated on an average annual basis. Forested erosion rates were based primarily on 160 randomly chosen, carefully monitored, sample plots.

## SEDIMENT RATES

Stream sediment sampling was conducted on 14 stream gauging stations and total suspended and bedload sediment estimated on an average annual basis. This information was translated into sediment rates per acre by the use of previously determined erosion rates and erosion/sediment delivery ratios.

## COSTS

Costs of various treatment measures were provided on a per acre basis by the Soil Conservation Service and the Forest Service. All costs were based on 1975 prices and amortized.

## ACRES

Acres of each sediment source were determined for broad erosion source categories primarily by satellite telemetry<sup>1/</sup> and checked by comparative aerial photography and by extensive ground proofing. (Herzog, et. al)

## SUB-BASINS

For purposes of identifying as closely as possible the specific area where treatment measures apply, 11 forested sub-basins and 5 sub-basins adjacent to the bay were delineated by the Forest Service and the Soil Conservation Service. The sub-basins adjacent to the bay were termed "agricultural" lands, although included within this category are acreages of urban and other lands.<sup>2/</sup>

## CONSTRAINTS

Constraints were set for several control measures and sediment sources. Constraints affect the number of acres that may enter the solution at a given percent sediment reduction.

The model was constrained to force tree planting on clearcuts and burns with greater than 50 percent bare ground. For the 10 percent sediment reduction, at least one-fourth of the total clearcut and burned areas with 50 percent or more bare ground were required to be planted to trees. The 20 percent sediment reduction brought in at least one-half of the available areas, and the remaining sediment reduction levels forced tree planting on all the available clearcuts and burned areas with 50 percent or more bare ground. If tree planting had originally been given a negative cost to account for positive average annual benefits from the future sale of timber, then tree planting would have undoubtedly entered the solutions more frequently as a sediment control measure. Thus tree planting was forced into the model as an attempt to recognize future benefits of timber harvests.

<sup>1/</sup> The Pical System (PIXSYS), earlier referred to as COVEDS (Coordinated Vegetation Digital Study), at Oregon State University (OSU) was used to obtain digitized base maps which provided acres of basic erosion source areas.

<sup>2/</sup> At the beginning of the study, five sub-basins covering the entire Tillamook Drainage were considered sufficient. However, as the study progressed it was found that significant differences in erosion rates existed between areas. In order to more specifically account for differences in erosion rates and to allow for more precise allocations of any future funds to be designated for erosion and sediment control, it was decided to expand the number of sub-basins from 5 to a total of 16.

The only other set of constraints pertaining to forested lands relate to spur roads, skid roads, and motor bike trails. These particular roads and trails were observed to be a potential causal factor of severe sediment problems on other source areas; e.g., gulleys starting from roads and trails that cut into areas with no previous erosion problems.

To take this factor into account, the control measure "stabilize and close roads" was required for spur roads, skid roads, and motor bike trails as follows. At the 10 and 20 percent levels no constraints were imposed. At the 30 percent reduction 3 percent of the area in these 3 source categories was marked for stabilization and closure; at the 40 percent level, 16 percent of the area was set; at the 50 percent level, 67 percent; and for the 60 percent and maximum levels of reduction, all of these 3 categories of roads and trails were required to be stabilized and closed.

For agricultural lands, constraints were placed on certain sediment source combinations of pasture and brush. These constraints account for the fact that of the total acreage of pasture and brush combinations, not all acreages have a problem severe enough to warrant treatment. Constraints on these sources recognize an upper limit of acreages on which treatment measures would be effective. Measures constrained were access trails, deferred grazing, and fencing.

Also, for agricultural lands, small acreages of rock riprap were constrained into the solutions. Rock riprap is an on-going standard solution for critical channel bank erosion, and by requiring at least a minimum number of acres of this treatment, it is recognized that rock riprapping will continue to be an accepted practice for treating critical channel erosion. Areas selected for rock riprapping are seldom amenable to effective erosion control by any other treatment measure. (Actually, the rock riprap constraint has little effect since this measure had been entering the solutions on earlier, unconstrained runs of the model. Rock riprap is a highly effective means of controlling sediment compared to other control measures, and while costly, is still economically efficient when looked at in terms of the cost per ton of sediment reduction.)

Another constraint limited the number of dryland pasture acres that could be irrigated under the control measure - plow, seed, fertilize, and irrigate grass. Water available for irrigation was the limiting factor for this control measure.

Also, on agricultural lands, two corrections were handled via constraints, 1) access trails were not allowed on channel bank cattle access, and 2) new irrigation of brush pasture was eliminated.

An example of the above constraints is shown on Table IX-6 for the Tillamook sub-basin.

## ANALYSES

A basic objective of this study was to determine various means of reducing sediment entering Tillamook Bay. An objective of the economic analysis was to achieve sediment reduction at least cost.

To accomplish the economic objective, least cost solutions were found for seven levels of sediment reduction. These seven levels represent reductions in average annual sediment entering the Bay. The levels of reduction are spaced at 10 percent intervals, from a 10 percent reduction, to the maximum reduction (64 percent). Reduction levels were figured using the 1975 base year rate, 60,606 tons, as a starting point. For example, to achieve a 50 percent reduction, average annual sediment would need to be reduced by 30,303 tons.

To obtain the seven least cost solutions, per acre sediment rates and costs of control measures for all 16 sub-basins were analyzed simultaneously. By analyzing all components of the Tillamook drainage simultaneously, least cost solutions are assured at each level of sediment reduction.<sup>1/</sup>

The detailed linear programming outputs are presented in the Appendix. Detailed outputs include control measure solutions, by sediment source for each of the 16 sub-basins and for all 7 reduction levels. Summaries of the detailed appendix material are presented throughout the remainder of this report. An example of a detailed output follows.

## SELECTED EXAMPLE

The computer linear programming outputs are presented in the Appendix. For illustrative purposes, five detailed appendix tables are shown here (Tables IX-7 through IX-11). This example shows control measures needed in the Lower Kilchis sub-basin for a 20 percent Tillamook Drainage overall reduction level. Tables IX-7 and IX-8 show the control measures required by sediment source. Agricultural and forested lands components are shown separately. Tables IX-9 and IX-10 summarize data presented in the previous two tables. The overall 20 percent solution is summarized for all 16 sub-basins in the Tillamook Drainage Basin on Table IX-11.

Four of the twenty-eight control measures entered the 20 percent least-cost solution for the Kilchis, Lower Main Stem.

<sup>1/</sup> If analyses had been conducted separately by component parts; i.e., by sub-basins, the summed total of the individual solutions would not be an overall least cost solution.

Table IX-6.--Sediment model constraints, Tillamook River, Tillamook Bay Drainage Basin, 1975

Sediment Source	plow, seed, ferti- lize & irrigate grass	Rock riprap	Portable electric fence	Deferred grazing	Access trails	Plant trees	Stabilize and close roads	Constraint applies to sediment reduction levels
-----Acres-----								
Tillamook Subbasins:								
Sediment reduced 10 percent:								
Agricultural lands:								
Dryland pasture.....	≤ 300		≤ 300	≤ 450	≤ 200			10 thru Max
Brush pasture.....	= 0		≤ 100	≤ 200	≤ 100			10 thru Max
Brush-hardwood.....			≤ 30	≤ 30	≤ 60			10 thru Max
Brush-Douglas Fir.....			≤ 20	≤ 25				10 thru Max
Pasture-Douglas Fir.....			≤ 150	≤ 150				10 thru Max
Channel erosion critical....		≥ 0.04						10 only
Channel bank cattle access...					= 0			10 thru Max
Forested lands:								
Clearcuts, > 75% bare.....						≥ 215		10 only
Clearcuts, 50-75% bare.....						≥ 222.5		10 only
Sediment reduced 20 percent:								
Channel erosion critical....		≥ 0.15						20 thru Max
Clearcuts, > 75% bare.....						≥ 430		20 only
Clearcuts, 50-75% bare.....						≥ 445		20 only
Sediment reduced 30 percent:								
Spur one-track roads.....						≥ 3.27		30 only
Skid roads 1/2 track.....						≥ 6.55		30 only
Motor bike trails.....						≥ 0.09		30 only
Clearcuts, > 75% bare.....						≥ 860		30 thru Max
Clearcuts, 50-75% bare.....						≥ 890		30 thru Max
Sediment reduced 40 percent:								
Spur one-track roads.....						≥ 17.44		40 only
Skid roads 1/2 track.....						≥ 34.91		40 only
Motor bike trails.....						≥ 0.50		40 only
Sediment reduced 50 percent:								
Spur one track roads.....						≥ 73.03		50 only
Skid roads 1/2 track.....						≥ 146.19		50 only
Motor bike trails.....						≥ 2.08		50 only
Sediment reduced 60 percent:								
Spur one track roads.....						≥ 109.0		60 and Max
Skid roads 1/2 track.....						≥ 218.2		60 and Max
Motor bike trails.....						≥ 3.1		60 and Max

TABLE IX-77 --- SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE  
 --- EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM  
 --- AGRICULTURAL LANDS COMPONENT  
 --- LEAST COST SOLUTION, 1975

MAJOR SEDIMENT SOURCE	TOTAL	NO NEW	SEDIMENT CONTROL MEASURES		
	AREAS	CONTROL	ROCK RIP RAP	PORTABLE ELECTRIC FENCE	TOTAL AREA TREATED
	BY SOURCE	MEASURES			
ACRES					
FARMLANDS:					
IRRIGATED PASTURE - - - - -	460.00	460.00	-	-	-
DRYLAND PASTURE - - - - -	1947.10	1947.10	-	-	-
BRUSH PASTURE - - - - -	210.00	210.00	-	-	-
BRUSH - HARDWOOD - - - - -	120.00	120.00	-	-	-
BRUSH - DOUGLAS FIR - - - - -	30.00	30.00	-	-	-
PASTURE - DOUGLAS FIR - - - - -	260.00	260.00	-	-	-
DOUGLAS FIR - - - - -	50.00	50.00	-	-	-
FIRST SEASON TILLAGE - - - - -	-	-	-	-	-
URBAN LANDS - - - - -	140.00	140.00	-	-	-
ROADS:					
PAVED - - - - -	90.00	90.00	-	-	-
GRAVEL - - - - -	34.00	34.00	-	-	-
STREAMS:					
CHANNEL EROSION - - - - -	10.68	10.68	-	-	-
CHANNEL BANK CRITICAL - - - - -	.19	-	.19	-	.19
CHANNEL BANK, CATTLE ACCESS - - - - -	.13	-	-	.13	.13
STREAM BOTTOM SCOUR - - - - -	.40	.40	-	-	-
STREAM BOTTOM DEBRIS - - - - -	4.00	4.00	-	-	-
FLOOD PLAIN SCOUR - - - - -	5.00	5.00	-	-	-
MISCELLANEOUS:					
WATER - - - - -	231.29	231.29	-	-	-
GRAVEL OPERATIONS - - - - -	4.00	4.00	-	-	-
RIPPAPPED AREA - - - - -	3.21	3.21	-	-	-
TOTAL ACREAGE	7600.00	3599.68	.19	.13	.32
TONS PER YEAR					
SEDIMENT, BASE YEAR 1975 - - -	1483.49	1212.89	249.00	21.60	270.60
SEDIMENT REDUCTION - - - - -	-261.34	-	-249.00	-12.34	-261.34
SEDIMENT REMAINING - - - - -	1222.15	1212.89	-	9.26	9.26
DOLLARS					
COST OF CONTROL MEASURES, 1975	-	-	652.24	.83	653.07

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE; ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

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 TABLE IX-8 --SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE  
 --EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM  
 --FORESTED LANDS COMPONENT  
 --LEAST COST SOLUTION, 1975  
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MAJOR SEDIMENT SOURCE	TOTAL AREAS BY SOURCE	NO NEW CONTROL MEASURES	SEDIMENT CONTROL MEASURES		
			PLANT BRUSH ON STREAMSIDE	PLANT TREES	TOTAL AREA TREATED
			ACRES		
FOREST COVER:					
BRUSH AND SEEDLINGS - - - - -	740.00	740.00	-	-	-
SAPLING AND POLES - - - - -	4870.00	4870.00	-	-	-
MATURE SECOND GROWTH - - - - -	3690.00	3690.00	-	-	-
HARDWOODS - - - - -	2800.00	2800.00	-	-	-
OLD GROWTH - - - - -	130.00	130.00	-	-	-
ROADS AND TRAILS:					
PAVED - - - - -	8.00	8.00	-	-	-
GRAVEL TWO TRACK - - - - -	533.00	533.00	-	-	-
SECONDARY ONE + A HALF TRACK - - - - -	466.00	466.00	-	-	-
SPUR ONE TRACK - - - - -	84.00	84.00	-	-	-
SKID ROAD, HALF TRACK - - - - -	40.00	40.00	-	-	-
FIRE TRAILS - - - - -	7.00	7.00	-	-	-
RAIL GRADE - IN USE - - - - -	-	-	-	-	-
RAIL GRADE - ABANDONED - - - - -	6.00	6.00	-	-	-
POWER LINE CORRIDORS - - - - -	24.00	24.00	-	-	-
MOTOR BIKE TRAILS - - - - -	1.00	1.00	-	-	-
LANDSLIDES:					
UPPER THIRD SLOPE - - - - -	198.00	198.00	-	-	-
MIDDLE THIRD SLOPE - - - - -	66.00	66.00	-	-	-
LOWER THIRD SLOPE - - - - -	51.00	51.00	-	-	-
STREAMS:					
CHANNEL BANK - - - - -	5.00	-	5.00	-	5.00
CHANNEL BOTTOM - - - - -	8.00	8.00	-	-	-
FLOOD PLAIN - - - - -	3.00	3.00	-	-	-
CLEARCUTS:					
> 75 % BARE GROUND - - - - -	150.00	75.00	-	75.00	75.00
50 - 75 % BARE GROUND - - - - -	180.00	90.00	-	90.00	90.00
25 - 50 % BARE GROUND - - - - -	450.00	450.00	-	-	-
0 - 25 % BARE GROUND - - - - -	420.00	420.00	-	-	-
BURNS:					
> 75 % BARE GROUND - - - - -	-	-	-	-	-
50 - 75 % BARE GROUND - - - - -	-	-	-	-	-
25 - 50 % BARE GROUND - - - - -	50.00	50.00	-	-	-
0 - 25 % BARE GROUND - - - - -	-	-	-	-	-
MISCELLANEOUS:					
WATER - - - - -	20.00	20.00	-	-	-
SAND BEACH - - - - -	-	-	-	-	-
POCK - - - - -	10.00	10.00	-	-	-
TOTAL ACREAGE	15010.00	14840.00	5.00	165.00	170.00

	TONS PER YEAR				
SEDIMENT, BASE YEAR 1975 - - -	2308.69	1590.59	510.00	208.10	719.10
SEDIMENT REDUCTION - - - - -	-292.84	-	-251.03	-41.77	-292.34
SEDIMENT REMAINING - - - - -	2015.85	1590.59	258.92	166.33	426.76
	DOLLARS				
COST OF CONTROL MEASURES, 1975	-	-	172.55	3285.15	3457.70

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE; ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

TABLE IX-99. ---SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE  
 ---EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM  
 ---AGRICULTURAL LANDS COMPONENT  
 ---LEAST COST SOLUTION, 1975

KILCHIS RIVER, LOWER MAIN STEM SUB-BASIN SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA
AREA	.32	3599.68	3600.00
		ACRES	
GROSS SEDIMENT:		TONS	
BASE YEAR, 1975	270.60	1212.99	1483.49
SEDIMENT REDUCTION	-261.34	-	-261.34
SEDIMENT REMAINING	9.26	1212.89	1222.15
		TONS PER ACRE	
AVERAGE SEDIMENT PER ACRE:			
BASE YEAR, 1975	845.63	.34	.41
SEDIMENT REDUCTION	-816.69	-	-0.07
SEDIMENT REMAINING	28.94	.34	.34
	DOLLARS		
CONTROL MEASURE COSTS, TOTAL	653.07		
	DOLLARS PER ACRE		
AVERAGE COST PER ACRE	2040.84		
	DOLLARS PER TON		
AVERAGE COST PER TON REDUCTION	2.50		

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE; ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

TABLE IX-10. --SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE  
 --EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM  
 --FORESTED LANDS COMPONENT  
 --LEAST COST SOLUTION, 1975

KILCHIS RIVER, LOWER MAIN STEM SUB-BASIN SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA
AREA	170.00	14810.00	15010.00
GROSS SEDIMENT: BASE YEAR, 1975	718.10	1590.59	2308.69
SEDIMENT REDUCTION	-292.84	-	-292.84
SEDIMENT REMAINING	425.26	1590.59	2015.85
AVERAGE SEDIMENT PER ACRE: BASE YEAR, 1975	4.22	.11	.15
SEDIMENT REDUCTION	-1.72	-	-0.02
SEDIMENT REMAINING	2.50	.11	.13
CONTROL MEASURE COSTS, TOTAL	3457.70		
AVERAGE COST PER ACRE	20.34		
AVERAGE COST PER TON REDUCTION	11.81		

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE;  
 ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE  
 OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

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TABLE IX-11 --SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE  
 --EFFECTS ON THE TILLAMOOK BAY DRAINAGE  
 --ALL LANDS  
 --LEAST COST SOLUTION, 1975

TILLAMOOK BAY DRAINAGE OVERALL SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA
	ACRES		
AREA - - - - -	2181.87	351998.13	354180.00
	TONS		
GROSS SEDIMENT: - - - - -	17941.57	42654.24	60595.59
BASE YEAR, 1975 - - - - -	-12111.33	-	-12121.11
SEDIMENT REDUCTION - - - - -	5830.24	42654.24	48484.48
SEDIMENT REMAINING - - - - -			
	TONS PER ACRE		
AVERAGE SEDIMENT PER ACRE: - - - - -	8.22	.12	.17
BASE YEAR, 1975 - - - - -	-5.55	-	-0.03
SEDIMENT REDUCTION - - - - -	2.67	.12	.14
SEDIMENT REMAINING - - - - -			
	DOLLARS		
CONTROL MEASURE COSTS, TOTAL - -	63348.35		
	DOLLARS PER ACRE		
AVERAGE COST PER ACRE - - - - -	29.03		
	DOLLARS PER TON		
AVERAGE COST PER TON REDUCTION -	5.23		

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE; ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

Sediment is reduced by 260 tons per year on agricultural lands, and by 290 tons per year on forested lands. The total reduction is 550 tons, or 15 percent. To achieve the overall Tillamook Drainage reduction of 20 percent, sediment reduction in other sub-basins was greater than 20 percent. A total of 2,182 acres would be treated to achieve the 20 percent reduction; 351,998 acres would require no new control measures (Table IX-11). <sup>1/</sup>

The annual amortized least-cost solution of a 20 percent reduction is \$63,348, or \$5.23 per ton per year of sediment reduction (Table IX-11). <sup>2/</sup> The Kilchis, Lower Main Stem share of this cost is \$653 for the agricultural component and \$3,458 for the forested component (Tables IX-7 and IX-8).

All costs shown in the detailed linear programming output tables are annual amortized (Tables IX-7 through IX-11, and Appendix). Annual amortization was necessary for valid analyses and comparisons of sediment control measures in the model.

Amortized costs should not be confused with initial capital requirements necessary for installation of control measures. Initial capital requirements, or installation costs, are summarized in tables IX-18 and X-1, and presented in detail by sediment source area and treatment measure in Table IX-19.

## SUMMARIES OF RESULTS

### Treatments

Acreages of treatment required for specified least-cost reductions of sediment varied greatly (Tables IX-12 and IX-13). For example, as one might expect, the areas of rock riprap are relatively small since not many areas would be amenable to this method of channel bank stabilization. On the other hand, large tracts of forest lands are amenable to the planting and fertilization of trees as shown for the maximum sediment reduction where 38,500 acres entered the least-cost solution.

Some interesting results are shown on Tables IX-12 and IX-13 that had not been expected. Several treatment measures did not enter any of the solutions; i.e., planting brush on landslides, seeding trees, gravelling surfaces of roads, and building check

<sup>1/</sup> It was assumed that control measures in effect previous to this study would be continued.

<sup>2/</sup> Costs were amortized at 6 5/8 percent, the current rate of interest used for federal water resource projects set by the Water Resources Council.

Table IX-12--Least cost sediment control measures, forested lands, Tillamook Bay Drainage Basin, 1975

Sediment Control Measures	Percentage Sediment Reduction						Max (64%)
	0	10%	20%	30%	40%	50%	60%
-----Acres-----							
Seed grass.....	0	0	0	0	1,083.37	10,204.63	9,087.68
Seed & fertilize grass.....	0	0	0	0	0	3,394.81	13,557.32
Seed, fertilize, mulch, & net grass....	0	0	0	0	0	0	4,775.12
Seed, mulch, terrace, & fert. grass...	0	0	0	0	0	163.00	1,604.00
Plant brush on stream sides.....	0	29.69	22.41	89.60	100.60	101.60	101.60
Plant brush on land sides.....	0	0	0	0	0	0	0
Plant trees.....	0	1,058.63	2,117.25	4,244.50	4,235.50	4,234.50	5,714.50
Seed trees.....	0	0	0	0	0	0	0
Trees, grass, & fertilize.....	0	0	0	175.00	848.00	3,262.00	23,363.00
Water bar & vegetate.....	0	0	0	0	0	0	0
Gravel surface.....	0	0	0	0	0	0	0
Stabilize & close roads.....	0	0	0	139.48	743.89	3,115.03	4,628.18
Gravel surface & hydromulch.....	0	0	0	0	0	0	0
Seed mulch, fert., & rock buttress....	0	0	0	0	0	0	25.00
Rock riprap.....	0	0	0	6.00	27.60	58.83	70.83
Back slope & plant brush.....	0	0	36.42	66.83	43.23	12.00	0
Check dams.....	0	0	0	0	0	0	0
Debris & log jam removal.....	0	0	0	38.67	107.70	137.77	137.77
TOTAL ACRES TREATED.....	0	1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	63,065.00
TOTAL ACRES NOT TREATED.....	324,230.00	323,141.58	322,053.92	319,469.92	317,040.11	299,545.83	261,165.00
TOTAL ACRES.....	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

Table IX-13--Least cost sediment control measures, agricultural lands, Tillamook Bay Drainage Basin, 1975

Sediment Control Measures	Percent Sediment Reduction							Max (64%)2/	
	0	1/	10%	20%	30%	40%	50%		60%
-----Acres-----									
Seed grass.....	0		0	0	0	0	0	0	0
Seed, mulch, fert., grass.....	0		0	0	0	0	0	0	1,135.70
Seed & mulch grass.....	0		0	0	0	0	0	0	34.00
Plow, seed, & fert. grass.....	0		0	0	0	0	0	0	12,079.28
Plow, seed, fert., irr. grass..	0		0	0	0	0	0	0	1,170.00
Backslope & revegetate.....	0		0	0	0	0	0	40.07	44.07
Remove stream debris.....	0		0	0	3.82	44.70	84.77	73.05	78.05
Rock pit run.....	0		0	0	.84	.84	.84	.84	.90
Rock riprap.....	0		1.23	4.89	4.89	4.89	4.89	4.89	30.61
Portable electric fence.....	0		.90	.84	0	0	0	401.00	1,245.00
Deferred grazing.....	0		0	.06	.06	.06	.06	.06	1,957.00
Access trails.....	0		0	0	0	0	0	0	1,015.00
TOTAL ACRES TREATED.....	0		2.13	5.79	9.61	50.49	90.56	519.91	18,789.61
TOTAL ACRES NOT TREATED.....	29,920		29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	29,430.09	11,160.39
TOTAL ACRES.....	29,950		29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00

<sup>1/</sup> This column represents the 1975 base year situation. Many control measures were in effect in 1975 and more have been installed since then. This study begins from the base year situation and looks at measures in addition to those already being applied at that time.

<sup>2/</sup> This is the maximum sediment reduction possible, given the input data rates per acre.

dams on forested lands and seeding grass on agricultural lands. Other measures that had relatively high costs and little effect on sediment reduction were forced into the solution only at the maximum reduction; i.e., water bar and vegetate, and gravel hydromulch road surfaces on forested lands, and seed mulch and fertilize grass, seed and mulch grass, plow seed and fertilize grass, plow and fertilize and irrigate grass, and construction of cattle access trails on agricultural lands. Other measures entered a solution set, increased, and phased back out at higher reduction levels; i.e., seeding grass, and backsloping and planting brush on forested lands.

An important finding from Tables IX-12 and IX-13 is that decision makers and planners should use caution in setting sediment reduction planning goals. Each level of sediment reduction represents a least-cost solution only for that level. If, for example the 60 percent level of reduction were to be chosen as a planning goal, planners might be tempted to reach that goal by first accomplishing lower levels of reduction such as the 50 percent level. Using the 50 percent level as a "stepping stone" to the 60 percent level may be all right as long as the acres of treatment measures for the 50 percent level were also called for at the 60 percent level. Backsloping and planting the 12 acres of brush called for at the 50 percent level would be a waste of money at the 60 percent level, where this measure is not part of the solution. Thus, while admitting that decision makers will have a difficult task in determining a sediment-reduction goal, such a determination could be more efficient in the long run.

#### Sub-Basins

The next summary is a presentation of the acres of reduction levels that enter the solutions for each sub-basin (Tables IX-14 and IX-15). All sub-basins are affected at every reduction level. However, for some sub-basins, substantially fewer acres would need to be treated compared to other sub-basins. For example, at the 30 percent level the least-cost solution calls for only .32 acres to be treated on agricultural lands in the Kilchis, Lower Sub-basin, compared to 1,779.61 acres on forested lands in the Tillamook Sub-basin.

A few more interesting facts can be learned from Tables IX-14 and IX-15. At the 60 percent reduction level only 519.91 acres (Table IX-14) would be treated on agricultural lands, or about 2 percent of the total agricultural acres. But to achieve the maximum reduction of 64 percent, nearly two-thirds of all the agricultural acres would have to be treated. An additional 18,269.7 acres would be treated (from 519.91 to 18,789.61 acres) to gain only an additional 4 percent sediment reduction (from 60-64 percent). A similar analogy holds for forested lands. Yet when looking at the Tillamook Bay Drainage Basin, less than one-third of the

Table IX-14 --Least cost control measure acreages by sub-basin for specified percentage reductions in sediment, agricultural lands, Tillamook Bay Drainage Basin, 1975

Sub-basin	Total Acres	Percent Sediment Reduction					Max (64)	
		10	20	30	40	50		60
-----Acres-----								
Tillamook.....	9,570.00	.29	.40	.40	5.90	5.90	284.25	6,909.25
Miami.....	1,260.00	.08	.15	3.97	8.27	8.27	113.27	1,008.95
Kilches lower.....	3,600.00	.18	.32	.32	15.40	15.40	54.40	688.40
Wilson lower.....	4,430.00	.21	.35	.35	7.75	24.78	31.78	2,565.10
Trask main.....	11,090.00	1.37	4.57	4.57	13.17	36.21	36.21	7,617.91
TOTAL ACRES TREATED.....		2.13	5.79	9.61	50.49	90.56	519.91	18,789.61
TOTAL ACRES NOT TREATED.		29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	29,430.09	11,160.39
TOTAL ACRES.....	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00

Table IX-15--Least cost control measure acreages, by sub-basin, for specified percentage reductions in sediment, forested lands, Tillamook Bay Drainage Basin, 1975

Sub-basin	Total Area	Percentage Sediment Reduction						
		10	20	30	40	50	60	Max (64)
-----Acres-----								
Tillamook.....	33,570	444.10	881.60	1,779.61	2,189.84	3,562.68	5,837.00	9,597.00
Miami.....	24,290	243.63	492.75	990.58	1,014.76	1,302.67	3,791.00	7,318.00
Kilches Lower.....	15,010	82.50	170.00	341.75	417.00	1,090.47	2,713.00	2,750.00
Kilches Upper.....	21,400	12.50	25.00	61.85	87.20	387.67	2,217.00	7,912.00
Kilches South.....	6,910	5.00	10.73	23.58	86.93	817.34	1,255.00	1,255.00
Wilson Lower.....	47,720	79.59	167.00	379.12	776.64	1,607.76	10,019.00	10,430.00
Wilson Upper.....	56,960	60.00	128.00	281.25	428.00	1,745.72	8,636.00	16,708.00
Wilson North.....	16,430	32.50	65.00	138.86	172.92	326.10	901.00	2,497.00
Trask Main.....	69,920	115.00	215.00	670.93	862.72	9,696.56	20,179.00	20,505.00
Trask East.....	18,830	6.00	6.00	50.66	1,088.60	3,895.99	6,086.00	6,098.00
Trask South.....	13,190	7.50	15.00	41.89	65.28	251.21	1,431.00	4,748.00
TOTAL ACRES TREATED.....		1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	63,065.00	89,818.00
TOTAL ACRES NOT TREATED.....	324,230	323,141.68	322,053.92	319,469.92	317,040.11	299,545.83	261,165.00	234,412.00
TOTAL ACRES.....	324,230	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

total area, 31 percent, would need to be treated for the maximum sediment reduction. Also surprising, is that at the lower reduction levels, not a very large portion of the total area would need to be treated; e.g., only 1,090.45 acres (.3 percent) for a 10 percent sediment reduction.

### Source Areas

The next two tables (Tables IX-16 and IX-17) show acres treated by sediment source areas.

Table IX-16, for agricultural lands, shows that channel erosion and cattle accesses need to be treated at the lower sediment reduction levels to attain the least-cost solutions. Stream-bottoms enter the solution at the 40 percent level. The other sediment sources do not enter until the 60 percent and the maximum reductions are required.

On forested lands (Table IX-17) channel banks, clearcuts, and burns would be treated at the 10 and 20 percent reduction levels. At the 30 percent reduction level some roads and trails, landslides, channel bottoms and flood plains begin to enter the solution. Some source areas would not be treated until the 60 percent and maximum sediment reduction levels; i.e., fire trails, railroad grades, power line corridors, clearcuts with less than 50 percent bare ground, and burns with less than 25 percent bare ground.

It is interesting to note that there is more area in roads and trails (32,941.3 acres) than there is in streams and floodplains (310.2 acres) on forested lands (in fact, roads and trails are over 100 times the area of streams and floodplains). Roads and trails account for more than 10 percent of the total forested land area of the basin.

While acreages of control measures by source (Tables IX-16 and IX-17), and by sub-basin (Tables IX-14 and IX-15), always increase from the lower to the higher levels of sediment reduction, the acreages by control measure (Tables IX-12 and IX-13) jump around some; e.g., backsloping and planting brush on forested lands. This phenomenon is to be expected since some control measures are relatively less expensive in terms of dollars per ton of reduction, but do not decrease sediment as much as other more expensive measures. Thus, as gross sediment is "tightened down," the more cost-efficient measures enter at the lower reduction levels, but yield to less cost-efficient measures at higher reduction levels.

Table IX-16-Least cost sediment control measures by sediment source, at specified levels of reduction, Tillamook Bay Drainage Basin, 1975

Sediment Source	Total Acres	Percentage Sediment Reduction					Max (64)
		10	20	30	40	50	
-----Acres-----							
Farmlands:							
Irrigated pasture.....	3,887.50	0	0	0	0	0	200.00
Dryland pasture.....	16,476.38	0	0	0	0	0	14,669.28
Brush pasture.....	1,330.00	0	0	0	0	0	1,330.00
Brush-hardwood.....	390.00	0	0	0	0	0	300.00
Brush-Douglas Fir.....	420.00	0	0	0	0	0	45.00
Pasture-Douglas Fir.....	2,300.00	0	0	0	0	0	905.00
Douglas Fir.....	170.00	0	0	0	0	0	0
First season tillage.....	712.50	0	0	0	0	0	0
Subtotal.....	(25,686.38)					(350.00)	(17,449.28)
Urban lands.....	1,730.00	0	0	0	0	0	0
Roads:							
Paved.....	901.20	0	0	0	0	0	901.20
Gravel.....	268.50	0	0	0	0	0	268.50
Subtotal.....	(1,169.70)					(34.00)	(1,169.70)
Streams:							
Channel erosion.....	82.92	0	0	3.82	14.50	54.57	82.92
Channel bank, critical.....	4.89	1.23	4.89	4.89	4.89	4.89	4.89
Channel bank, cattle access....	.90	.90	.84	.84	.84	.84	.90
Stream bottom scour.....	2.20	0	0	0	2.20	2.20	2.20
Stream bottom debris.....	28.00	0	0	0	28.00	28.00	28.00
Floodplain scour.....	32.00	0	.06	.06	.06	.06	32.00
Subtotal.....	(150.91)	(2.13)	(5.79)	(9.61)	(50.49)	(90.56)	(150.91)
Miscellaneous:							
Water.....	1,169.43	0	0	0	0	0	0
Gravel operations.....	19.72	0	0	0	0	0	19.72
Riprap area.....	23.86	0	0	0	0	0	0
Subtotal.....	(1,213.01)						(19.72)
Total acres treated.....		2.13	5.79	9.61	50.49	90.56	18,789.61
Total acres not treated.....	29,950.00	29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	11,160.39
TOTAL ACRES.....	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00



Table IX-17--Least cost sediment control measures by sediment source, at specified levels of reduction, Tillamook Bay Drainage Basin, 1975, Continued.

Sediment Sources	Total Acres	Percentage Reduction				60%	Max (64%)
		10%	20%	30%	40%		
-----Acres-----							
<u>Burns:</u>							
>75% bareground.....	630.00	157.50	315.00	630.00	630.00	630.00	630.00
50-25% bareground.....	200.00	50.00	100.00	200.00	200.00	200.00	200.00
25-50% bareground.....	21,460.00	0	0	0	0	12,060.00	21,460.00
0-25% bareground.....	17,040.00	0	0	0	0	8,010.00	17,040.00
Subtotal.....	(39,330.00)	(207.50)	(415.00)	(830.00)	(830.00)	(20,900.00)	(39,330.00)
<u>Miscellaneous:</u>							
Water.....	519.50	0	0	0	0	0	0
Sandbeach.....	40.00	0	0	0	0	0	0
Rock.....	3,529.00	0	0	0	0	0	0
Subtotal.....	(4,088.50)	0	0	0	0	0	0
ACRES TREATED.....	0	1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	89,818.00
ACRES NOT TREATED.....	324,230.00	324,141.68	322,053.92	319,469.92	317,040.11	299,545.83	234,412.00
TOTAL ACREAGE.....	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

## Costs

What does all this mean in terms of costs? Shown on Table IX-18 are the amortized costs and the capital costs or installation costs at each percentage level reduction for the Tillamook Bay Drainage Basin. Also shown are the tons of sediment reduction and the tons of sediment remaining at each level.

Readily apparent from Table IX-18 is the fact that costs increase rapidly as sediment is reduced. Installation costs of 189 million dollars for the maximum reduction are substantially higher than the .38 million dollars required for the 10 percent reduction.

Installation capital costs are further broken down in Table IX-19 by reduction levels and treatment measures. Initial installation costs are significantly higher than amortized costs for the same treatment (except for those items where the project life is one year).

It should be pointed out that some control measures may be desirable or beneficial for reasons other than just sediment control. The particular sets of treatment measures at the various levels of reduction are the result of fulfilling a particular objective; namely, the least-cost reduction of sediment to Tillamook Bay. Many of the control measures considered in this study could be used to satisfy other objectives; i.e., erosion control, increased timberland productivity, better roads for hunters and recreationists, etc.

Table IX-18 -- Minimum costs of sediment reduction, Tillamook Bay Drainage Basin, 1975

Percentage reduction	Total sediment reduction	Amortized cost of control measures <sup>1/</sup>	Installation costs of control measures	Total sediment remaining
Percent	Thous. tons per year	-----Thousand dollars-----		Thous. tons per year
0	0	0	0	60 <sup>2/</sup>
10	6	26	381	54
20	12	63	893	48
30	18	171	2,504	42
40	24	369	5,338	36
50	30	1,046	15,510	30
60	36	2,754	41,040	24
Max (64) <sup>3/</sup>	39	14,143	189,035	21

<sup>1/</sup> With sediment constrained to the indicated percentage levels, these are the minimum amortized costs of achieving each level of reduction. The amortization interest rate was 6 5/8 percent, which is the rate used for federal water resource projects set by the Water Resources Council.

<sup>2/</sup> This row represents the 1975 base year situation. Many control measures were already in use in 1975, and more have been installed since. This study "takes off" from the base year and looks at measures in addition to those already being applied at that time.

<sup>3/</sup> Maximum sediment reduction possible, given the input data control measure rates, costs, and constraints for the 1975 base year.

Table IX-19--Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975

Sediment reduction levels and treatment measures		Area	Installation, capital costs	Amortized annual costs <sup>1/</sup>
		Acres	-----Dollars-----	
10%	Plant brush on streamsidess.....	29.69	15,439	1,025
	Plant trees.....	1,058.63	317,589	21,077
	Rock Riprap.....	1.23	48,216	4,222
	Portable electric fence.....	.90	5	6
	TOTAL.....	1,090.45	381,249	26,330
20%	Plant brush on streamsidess.....	22.41	11,653	773
	Plant trees.....	2,117.25	635,175	42,154
	Backslope & plant brush.....	36.42	54,630	3,626
	Rock Riprap.....	4.89	191,688	16,787
	Portable electric fence.....	.84	5	5
	Deferred grazing.....	.06	3	3
	TOTAL.....	2,181.87	893,154	63,348
30%	Plant brush on streamsidess.....	89.60	46,592	3,161
	Plant trees.....	4,244.50	1,273,350	84,508
	Trees, grass & fertilize.....	175.00	105,000	6,969
	Stabilize & close roads.....	139.48	306,856	20,363
	Backslope & plant brush.....	66.83	100,245	6,453
	Debris & log jam removal.....	38.67	386,700	25,664
	Rock riprap, forest.....	6.00	90,000	5,972
	Rock riprap, agric.....	4.89	191,688	16,787
	Rock pit run.....	.84	2,688	457
	Deferred grazing.....	.06	3	3
	Remove stream debris.....	3.82	573	611
	TOTAL.....	4,769.69	2,503,695	170,948
40%	Plant brush on streamsidess.....	100.60	52,312	3,472
	Plant trees.....	4,235.50	1,270,650	84,329
	Trees, grass, & fertilize.....	848.00	508,800	33,767
	Stabilize & close roads.....	743.89	1,636,558	108,600
	Seed grass.....	1,083.37	162,506	10,780
	Backslope & plant brush.....	43.23	64,845	4,303
	Debris & log jam removal.....	107.70	1,077,000	71,471
	Rock riprap, forest.....	27.60	414,000	27,472
	Rock riprap, agric.....	4.89	191,688	16,787
	Rock pit run.....	.84	2,688	457
	Deferred grazing.....	.06	3	3
	Remove stream debris.....	44.70	6,705	7,149
	TOTAL.....	7,240.38	5,387,754	386,587

Continued

Table IX-19--Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975, Continued.

Sediment reduction levels and treatment measures	Area	Installation, capital costs	Amortized annual costs <sup>1/</sup>
	Acres	-----Dollars-----	
50% Plant brush on streamsides.....	101.60	52,832	3,506
Plant trees.....	4,234.50	1,270,350	84,309
Trees, grass, & fertilize.....	3,262.00	1,957,200	129,893
Stabilize & close roads.....	3,115.03	6,853,066	454,763
Seed grass.....	10,204.63	1,530,695	101,536
Seed & fertilize grass.....	3,394.81	1,018,443	67,591
Seed, mulch, terrace, & fert. grass....	163.00	342,300	22,714
Backslope & plant brush.....	12.00	18,000	1,194
Debris & log jam removal.....	137.77	1,377,700	91,423
Rock riprap, forest.....	58.83	882,450	58,558
Rock riprap, agric.....	4.89	191,688	16,787
Rock pit run.....	.84	2,688	457
Deferred grazing.....	.06	3	3
Remove stream debris.....	84.77	12,716	13,558
TOTAL.....	24,774.73	15,510,130	1,046,292
60% Plant brush on streamsides.....	101.60	52,832	3,506
Plant trees.....	5,714.50	1,714,350	113,776
Trees, grass, & fertilize.....	23,363.00	14,017,800	930,315
Stabilize & close roads.....	4,628.18	10,181,996	675,668
Seed grass.....	9,087.68	1,363,152	90,422
Seed & fertilize grass.....	13,557.32	4,067,196	269,926
Seed, fert., mulch, & net grass.....	4,775.12	2,865,072	190,145
Seed, mulch, terrace, & fert. grass....	1,604.00	3,368,400	223,517
Seed, mulch, fert. grass & rock buttress.....	25.00	500,000	33,179
Debris & log jam removal.....	137.77	1,377,700	91,423
Rock riprap, forest.....	70.83	1,062,450	70,503
Rock riprap, agric.....	4.89	191,688	16,787
Rock pit run.....	.84	2,688	457
Deferred grazing.....	.06	3	3
Backslope & revegetate.....	40.07	261,657	30,350
Remove stream debris.....	73.05	10,958	11,684
Portable electric fence.....	401.00	2,406	2,566
TOTAL.....	63,584.91	41,040,348	2,754,227

Continued

Table IX-19 --Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975, Continued

Sediment reduction levels and treatment measures	Area	Installation, capital costs	Amortized annual costs <sup>1/</sup>
	<u>Acres</u>	<u>Dollars</u>	
MAX			
64% Plant brush on streamsides.....	101.60	52,832	3,506
Plant trees.....	12,954.50	3,886,350	257,924
Trees, grass, & fertilize.....	38,500.00	23,100,000	1,533,070
Stabilize & close roads.....	4,649.30	10,228,460	678,751
Water bar & vegetate.....	948.00	1,659,000	110,091
Gravel surface & hydromulch.....	15,405.70	89,353,060	5,929,346
Seed & fertilize grass.....	183.50	55,050	3,653
Seed, fert., mulch & net grass.....	11,754.80	7,052,880	468,076
Seed, mulch, ter., & fert. grass.....	3,861.00	8,108,100	538,030
Seed, mulch, fert. & rock buttress....	1,251.00	25,020,000	1,660,290
Debris & log jam removal.....	137.77	1,377,700	91,443
Rock riprap, forest.....	70.83	1,062,450	70,503
Seed & mulch grass.....	34.00	5,100	1,231
Seed, mulch, & fert. grass.....	1,135.70	283,925	68,551
Plow, seed, & fert. grass.....	12,079.28	3,623,784	598,045
Plow, seed, fert. & irr. grass.....	1,170.00	468,000	77,243
Rock riprap, agric.....	30.61	1,199,912	105,079
Rock pit run.....	.90	2,880	489
Deferred grazing.....	1,957.00	97,850	104,328
Backslope & revegetate.....	44.07	287,777	33,380
Remove stream debris.....	78.05	11,708	12,483
Portable electric fence.....	1,245.00	7,470	7,968
Access trails.....	<u>1,015.00</u>	<u>12,090,680</u>	<u>1,789,161</u>
TOTAL.....	108,607.61	189,034,968	14,142,641

<sup>1/</sup> Annual costs were amortized at 6 5/8 percent, the rate set by the Water Resources Council to be used for federal water resource projects.

## CHAPTER X

### ALTERNATIVE PLANS (Formulation)



# ALTERNATIVE PLANS (Formulation)

## CONSIDERATION OF DIFFERENT CONTROL PROGRAMS

### ANALYSIS OF CONTROL PROGRAMS

Table X-1 summarizes the measure of fitness of alternative goals expressed in percentages of sediment reduction. There are several undetermined aspects of the study which leave the study team in an "if" and "assume" situation. Some of these aspects are as follows.

1. A sediment reduction goal has never been ascertained.
2. The inflow of marine sediments through the mouth of the estuary is not known.
3. The outflow of river-source sediments through the mouth of the estuary is not known.
4. The "in-bay" shifting of sediments is unknown.

The study team, through necessity, has set some "if" situations and made some "assumptions" which may be questioned, and hopefully will be closely examined. This has been done with the hope of activating thought processes which may result in answers to Items 1-4 and provide an integration of the data contained in this report with local land-use planning efforts.

Column 7, Achievement of desirable results, in the measure-of-fitness table (Table X-1) is based upon the following "ifs" and "assumptions" (Scenario A).

### Scenario A

1. All river-source sediments remain in the estuarine system.
2. No new marine sediments enter the estuary.
3. There is no shifting of sediments in the bay.
4. The in-bay sediments are, or will be, reduced to a desirable depth through bay sediment-removal programs.

Two levels of sediment reduction are considered under the scenario. The first level considered was to approach, as nearly as possible, the natural historic level. There is no accurate measurement of this condition; however, analysis presented earlier in this report indicates it was probably close to 3,000 tons per year. Total sediment reduction needed to reach this goal would be 58,000 tons, annually.

The second level considered was a reduction to that which would permit the U.S. Corps of Engineers to maintain an open bar and channel to Kilchis Point with two boat basins. This would mean that the Corps must expand their dredging program to maintain the additional area from Garibaldi to Kilchis Point, and that the sediment level would be reduced to that same equivalent. In this case, we assume a maintenance level of about 42,000 yards<sup>1/</sup> per year. Total sediment reduction necessary to meet this goal is about 19,000 tons, annually.

Other scenarios and levels could be assumed. The scenario and levels mentioned here, and shown on Table X-1, are for illustrative purposes to show how sediment reduction might affect hypothesized planning goals.

The basis for the measure of fitness, as summarized on Table X-1 utilizes a comparison of the cost of dredging and disposal of sediment from the bay as opposed to retaining the soils on site. The Corps of Engineers' dredging program in Tillamook Estuary has averaged 14,100 yards per year since 1970, at an average cost of \$1.70 per yard.

The Corps will soon (1979) be without a land-based spoil site to deposit in-bay dredging materials. Ocean disposal will add about \$1.50 per yard after 1979. Acquisition of lands to use for spoil at today's prices is nearly prohibitive, and in many cases, environmentally constrained.

Table X-1 provides a comparison of control programs on scenario levels. Also on Table X-1 are statements on cost effectiveness, public acceptance, and institutional constraints.

<sup>1/</sup> A cubic yard of sediment weighs between .98 and 1.08 tons; 1 ton per yard was used as the standard for this report.

Table X-1.-Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975

Planning Goals	Treatment measures <sup>1/</sup>	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints <sup>2/</sup>
10%	Plant brush on streamsid es Plant trees Plant trees Plant trees Plant trees Rock, rip rap Portable electric fence	Channel banks Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Channel erosion, critical Channel bank cattle access	29.65 353.63 497.50 157.50 50.00 1.23 .90	The 10% level of accomplishment would reduce annual sediment entering the stream systems by 6,060 cubic yards. <sup>3/</sup> The cost of dredging with marine disposal, \$3.20 per cubic yard, would be saved by not having to remove this material from the Bay. Other benefits such as increased timber production <sup>4/</sup> , reduced land losses, and increased employment are included in the annual net benefits of \$7.23 per cubic yard. The total average annual net benefit is \$43,830 from the 10% level.	Treatment measures selected at this level on agricultural lands are to stabilize eroding streambanks and livestock access trails by placement of rock rip rap on streambanks and placement of electric fence on the access trails. Both measures are being used effectively by the ongoing program. The problem sources selected for treatment are considered as critical, requiring extreme measures to hold the soil in place against very swift currents created by flood waters to which these areas are periodically exposed.  Treatment measures selected at this level on forested lands have long been accepted as not only desirable, but necessary, because of the effective control of erosion, also the environmental improvement, visual desirability, increased wildlife habitat which results, and increased production of wood fiber.	Objective, Scenario A. Level I - 10.4% of objective met. Level II - 31.9% of objective met.	The 10% level of accomplishment of sediment reduction will require a total (unamortized) expenditure of \$381,000 (at 1975 prices). Possibly, the 10% level could be obtained through a change in priorities by land managers in order to perform these jobs as opposed to other jobs.
20%	Plant brush on streamsid es Plant trees Plant trees Plant trees Plant trees Backslope & plant brush Rock, rip rap Portable electric fence Deferred grazing	Channel banks Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour	22.41 707.25 995.00 315.00 100.00 36.42 4.89 .84 .06	12,120 yards sediment reduction <sup>5/</sup> \$6.39 per yard net benefit \$77,440 total net benefit	The only new treatment measure brought in at this accomplishment level on forest lands is to backslope some streambanks prior to planting shrubs. These are well-established practices which are often necessary in certain situations if streambanks are to be successfully stabilized.	Objective, Scenario A, Level - 20.9% of objective met. Level II - 63.8% of objective met.	The 20% level of sediment reduction will require an expenditure of \$893,000. Such an amount would require changes in priorities and/or a source of cost-sharing funds for installation of control measures.  There may be some objection because of temporary disruption of the shoreline habitat by backsloping.
30%	Plant brush on streamsid es Plant trees Plant trees Plant trees Plant trees Plant trees Trees, grass & fertilize Trees, grass & fertilize Stabilize & close roads Stabilize & close roads Stabilize & close roads Stabilize & close roads Backslope & plant brush Debris & log jam removal Rock, rip rap Rock, rip rap Rock pit run Deferred grazing Remove stream debris	Flood plains Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Flood plains Landslides, middle 1/3 slope Landslides, lower 1/3 slope Spur roads, one track Skid roads, half track Motorbike trails Channel banks Channel bottoms Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour Channel erosion	89.60 1,394.50 1,880.00 650.00 310.00 10.00 70.00 105.00 69.12 55.63 14.73 66.83 38.67 6.00 4.89 .84 .06 3.82	18,180 yards sediment reduction <sup>5/</sup> \$5.63 per yard net benefit \$102,380 total net benefit	New treatment measures which come in at this accomplishment level include seeding grass and fertilizing; removing debris and log jams from stream channels; stabilizing and closing roads; and the placing of pit run rock on cattle access trails. Debris and log jam removal have often been questioned. The method of removal and the material to be removed must be carefully planned to avoid adverse impacts on environmental relationships such as a log-pool environment.	Objective, Scenario A, Level I - 31.3% of objective met. Level II - 95.7% of objective met.	At 30%, treatment measures will cost \$2,504,000. The increase in costs over the 20% level will require a re-ordering of priorities by land managers and a source of funding, possibly cost sharing, for installation of the control measures.  Debris and log jam removal may constitute a significant impact on the environment, which would require the EIS (Environmental Impact Statement) procedures. Coordination with fish and wildlife agencies would be necessary to plan and conduct the program.  Stabilization and closure of some roads may constitute an institutional constraint.



Table X-1.--Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975 (Continued)

Planning Goals	Treatment measures <sup>1/</sup>	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints <sup>2/</sup>
40%	Plant brush on streamsidess Plant trees Plant trees Plant trees Plant trees Plant trees Trees, grass & fertilize Trees, grass & fertilize Trees, grass & fertilize Stabilize & close roads Stabilize & close roads Stabilize & close roads Seed grass Seed grass Seed grass Backslope & plant brush Debris & log jam removal Rock, rip rap Rock, rip rap Rock, pit run Deferred grazing Remove stream debris Remove stream debris Remove stream debris	Flood plains Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Flood plains Landslides, upper 1/3 slope Landslides, middle 1/3 slope Landslides, lower 1/3 slope Spur roads, one track Skid roads, half track Motorbike trails Secondary roads, 1½ track Spur roads, one track Skid roads, half track Channel banks Channel bottoms Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour Channel erosion Stream bottom scour Stream bottom debris	100.60 1,414.50 1,990.00 630.00 200.00 1.00 68.00 223.00 557.00 368.64 296.67 78.58 827.00 73.08 183.29 43.23 107.70 27.60 4.89 .84 .06 14.50 2.20 28.00	24,240 yards sediment reduction <sup>5/</sup> - \$1.19 per yard net benefit - \$28,800 total net benefit	New treatment measures brought in at this accomplishment level include seeding on forest road ditches. Grass seeding is a well-established and accepted practice for soil stabilization on bare soils.	Objective, Scenario A, Level I - 41.8% of objective met. Level II - 127.6% of objective met.	Total cost of a 40% reduction is \$5,388,000. At 40%, net economic benefits are negative. Justification would have to be based on net beneficial environmental and/or social well-being effects. Comments for the 30% level apply here also.
50%	Plant brush on streamsidess Plant trees Plant trees Plant trees Plant trees Trees, grass & fertilize Trees, grass & fertilize Trees, grass & fertilize Trees, grass & fertilize Stabilize & close roads Stabilize & close roads Stabilize & close roads Seed grass Seed grass Seed grass Seed grass Seed grass Seed & fertilize grass Seed & fertilize grass Seed & fertilize grass Seed & fertilize grass Seed, mulch, ter & fert grass Seed, mulch, ter & fert grass Seed, mulch, ter & fert grass Backslope & plant brush Debris & log jam removal Rock, rip rap Rock, rip rap Rock, pit run Deferred grazing Remove stream debris Remove stream debris Remove stream debris	Flood plains Clearcuts, >75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns 50-75% bare ground Landslides, upper 1/3 slope Landslides, middle 1/3 slope Landslides, lower 1/3 slope Burns, 25-50% bare ground Spur roads, one track Skid roads, half track Motorbike trails Paved roads Gravel roads, two track Secondary roads, 1½ track Spur roads, one track Skid roads, half track Secondary roads, 1½ track Spur roads, one track Skid roads, half track Burns, 25-50% bare ground Landslides, upper 1/3 slope Landslides, middle 1/3 slope Landslides, lower 1/3 slope Channel banks Channel bottoms Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour Channel erosion Stream bottom scour Stream bottom debris	101.60 1,414.50 1,990.00 630.00 200.00 604.00 732.00 1,226.00 700.00 1,543.68 1,242.31 329.04 66.00 3,927.00 5,478.70 242.22 490.71 827.00 355.41 83.89 2,128.51 68.00 70.00 25.00 12.00 137.77 58.83 4.89 .84 .06 54.57 2.20 28.00	30,300 yards sediment reduction <sup>5/</sup> -\$17.20 per cubic yard net benefit -\$521,020 total net benefit	New treatment measures brought in under this accomplishment level are seeding grass, mulching, and terracing. These practices are recognized as effective measures to hold soils in place on extreme slopes and on soils which are difficult to hold in place after being mechanically disturbed. Comments under the 30% level of accomplishment are still applicable.	Objective, Scenario A, Level I - 52.2% of objective met. Level II - 159.5% of objective met.	Control measures would cost \$15,510,000 for a 50% sediment reduction. Statements for the 30 and 40 percent levels still apply.



Table X-1.-Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975 (Continued)

Planning Goals	Treatment measures <sup>1/</sup>	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints <sup>2/</sup>
( )%	Plant brush on streamsides	Flood plains	101.60	36,360 yards sediment reduction <sup>5/</sup>	New treatment measures brought in under this accomplishment level on agricultural areas are the use of electric fences to control livestock movement and backsloping and revegetation of streambanks adjacent to farmlands. Fencing is in current use on many of the dairies as a means to obtain optimum use of forage. Electric fences would effectively constrain livestock from areas with erosion potential. Rock buttressing is not included on forest areas. This is an extreme measure used when it is necessary to physically constrain a landslide on site.	Objective, Scenario A, Level I - 62.7% of objective met. Level II - 191.4% of objective met.	This set of treatment measures would cost \$41,040,000. Adverse net economic effects and the controversial nature of several control measures lessen the possibility that the 60% level of reduction could be justified. Comments for the 30 and 40 percent levels are still applicable.
	Plant trees	Clearcuts, > 75% bare ground	1,414.50	-\$34.61 per cubic yard net benefit			
	Plant trees	Clearcuts, 50-75% bare ground	1,990.00	-\$1,258,360 total net benefit			
	Plant trees	Clearcuts 25-50% bare ground	1,060.00				
	Plant trees	Clearcuts 0-25% bare ground	420.00				
	Plant trees	Burns, > 75% bare ground	630.00				
	Plant trees	Burns 50-75% bare ground	200.00				
	Trees, grass & fertilize	Landslides, upper 1/3 slope	2,226.00				
	Trees, grass & fertilize	Landslides, middle 1/3 slope	576.00				
	Trees, grass & fertilize	Landslides, lower 1/3 slope	681.00				
	Trees, grass & fertilize	Burns, 50-75% bare ground	5,980.00				
	Trees, grass & fertilize	Burns, 25-50% bare ground	10,100.00				
	Trees, grass & fertilize	Burns, 0-25% bare ground	3,800.00				
	Stabilize & close roads	Spur roads, one track	2,304.00				
	Stabilize & close roads	Skid roads, half track	1,833.08				
	Stabilize & close roads	Motorbike trails	491.10				
	Seed grass	Paved roads	10.00				
	Seed grass	Gravel roads, two track	1,521.00				
	Seed grass	Secondary roads, 1½ track	3,245.68				
	Seed grass	Burns, 25-50% bare ground	4,311.00				
	Seed & fertilize grass	Paved roads	217.60				
	Seed & fertilize grass	Gravel roads, two track	4,108.20				
	Seed & fertilize grass	Secondary roads, 1½ track	8,813.02				
	Seed & fertilize grass	Rail grades, abandoned	63.50				
	Seed & fertilize grass	Power line corridors	165.00				
	Seed & fertilize grass	Burns, 25-50% bare ground	190.00				
	Seed, fert, mulch & net grass	Gravel roads, two track	3,927.00				
	Seed, fert, mulch & net grass	Secondary roads, 1½ track	827.00				
	Seed, fert, mulch & net grass	Skid roads, half track	21.12				
	Seed, mulch, ter & fert grass	Landslides, upper 1/3 slope	291.00				
	Seed, mulch, ter & fert grass	Landslides, middle 1/3 slope	602.00				
	Seed, mulch, ter & fert grass	Landslides, lower 1/3 slope	711.00				
	Seed, mulch, fert grass & rock buttress	Landslides, lower 1/3 slope	25.00				
	Debris & log jam removal	Channel bottoms	137.77				
	Rock, rip rap	Channel banks	70.83				
	Rock, rip rap	Channel erosion, critical	4.89				
	Rock, pit run	Channel bank cattle access	.84				
	Deferred grazing	Flood plain scour	.06				
	Backslope & revegetate	Channel erosion	40.07				
	Remove stream debris	Channel erosion	42.85				
	Remove stream debris	Stream bottom scour	2.20				
	Remove stream debris	Stream bottom debris	28.00				
	Portable electric fence	Dryland pasture	100.00				
	Portable electric fence	Brush pasture	100.00				
	Portable electric fence	Pasture, Douglas Fir	150.00				
	Portable electric fence	Gravel roads	34.00				
	Portable electric fence	Flood plain scour	17.00				



Table X-1.-Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975 (Continued)

Planning Goals	Treatment measures <sup>1/</sup>	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints <sup>2/</sup>
Maximum	Plant brush on streamsidess Plant trees Plant trees Plant trees Plant trees Plant trees Plant trees Trees, grass & fertilize Trees, grass & fertilize Stabilize & close roads Stabilize & close roads Stabilize & close roads Water bar & vegetate Water bar & vegetate Gravel surface & hydromulch Seed & fertilize grass Seed & fertilize grass Seed, fert, mulch & net grass Seed, fert, mulch & net grass Seed, mulch, ter & fert grass Seed, mulch, ter & fert grass Seed, mulch, fert grass & rock buttress Debris & log jam removal Rock, rip rap Seed & mulch grass Seed, mulch & fertilize grass Seed, mulch & fertilize grass Plow, seed & fertilize grass Plow, seed & fertilize grass Plow, seed & fertilize grass Plow, seed, fert & irr grass Rock, rip rap Rock, rip rap Rock, rip rap Rock, pit run Deferred grazing Deferred grazing Deferred grazing Deferred grazing Deferred grazing Deferred grazing Backslope and revegetate Backslope and revegetate Remove stream debris Remove stream debris Remove stream debris Remove stream debris Portable electric fence Portable electric fence Portable electric fence Portable electric fence Portable electric fence Access trails Access trails Access trails Access trails Access trails	Flood plains Clearcuts > 75% bare ground Clearcuts 50-75% bare ground Clearcuts 25-50% bare ground Clearcuts 0-25% bare ground Burns > 75 % bare ground Burns 50-75% bare ground Burns 25-50% bare ground Burns 0-25% bare ground Spur roads, one track Skid roads, half track Motorbike trails Fire trails Powerline corridors Secondary roads, 1½ track Rail grades, in use Rail grades, abandoned Pavel roads Gravel roads, two track Landslides, upper 1/3 slope Landslides, middle 1/3 slope Landslides, lower 1/3 slope Channel bottoms Channel banks Gravel roads Paved roads Gravel roads Irrigated pasture Dryland pasture Brush pasture Dryland pasture Channel erosion Flood plain scour Gravel operations Channel bank cattle access Dryland pasture Brush pasture Brush, hardwood Brush, Douglas Fir Pasture, Douglas Fir Flood plain scour Channel erosion Gravel operations Channel erosion Stream bottom scour Stream bottom debris Flood plain scour Dryland pasture Brush pasture Brush, hardwood Brush, Douglas Fir Pasture, Douglas Fir Dryland pasture Brush pasture Brush, hardwood Brush, Douglas Fir Pasture, Douglas Fir	101.60 1,414.50 1,990.00 5,110.00 3,610.00 630.00 200.00 21,410.00 17,090.00 2,304.00 1,854.20 491.10 462.00 486.00 15,405.70 9.00 174.50 235.60 11,519.20 2,517.00 1,344.00 1,251.00 137.77 70.83 34.00 901.20 234.50 200.00 10,974.28 905.00 1,170.00 4.89 10.00 15.72 .90 1,250.00 210.00 90.00 30.00 360.00 17.00 40.07 4.00 42.85 2.20 28.00 5.00 700.00 100.00 80.00 20.00 345.00 575.00 115.00 60.00 5.00 260.00	38,800 yards sediment reduction <sup>5/</sup> -\$264.43 per cubic yard net benefit -\$10,259,830 total net benefit	New practices brought in on agricultural lands include plowing, irrigation, mulching, and construction of access trails. These are all well-established practices utilized by prudent land managers.  New practices brought in on forest lands include netting slopes, gravel surfacing, hydromulching, and water-barring. These practices are all commonly used by foresters in preventing soil movement on forest soils. Closing roads may be controversial in areas where off-road vehicle use has become established. Current damage to the soil and water resources should justify such action on specific roads and trails.	Objective, Scenario A, Level I - 66.9% of objective met. Level II - 204.2% of objective met.	For the maximum possible reduction of sediment, 64%, the cost is \$189,035,000.

1/ The model was constrained to reflect potential net profits from tree planting and to account for on-going programs on agricultural lands of placing rock rip rap. Also, road closure and stabilization was required on certain forested roads and trails to prevent potential erosion from occurring on other source areas. Constraints are discussed in detail in the previous chapter.

2/ Costs are total, unamortized, using 1975 prices.

3/ A cubic yard of sediment weighs between .90 and 1.08 tons; one ton per yard was used as the standard for this report.

4/ Benefits of timber harvest, 70 years hence, were depreciated and amortized for an average annual present value of \$44.90 per acre per year.

5/ For narrative, see the 10% level.



## COMPARISONS OF CONTROL PROGRAMS

Preceding sections of the report have shown how the study developed to this point. Sediment problems were defined, data were collected and analyzed, control measures were formulated, and least-cost combinations of control measures were established. Now these combinations of control measures will be examined to determine economic, environmental, and other effects. An analysis and comparison of these effects is required of all federally sponsored national resource studies.(16 and 43)

This evaluation of effects included beneficial and adverse impacts that the Study Team was able to ascertain at the time this report was written. Other beneficial and adverse effects may exist. Beneficial effects to the economic development account were especially difficult to determine. Several unknowns complicate the evaluation of the beneficial effects of sediment reduction. Some of these unknowns have been described earlier.

The most frustrating unknown relates to the problem of determining physical and economic effects of sediment impacts in the bay. While earlier sections of this report have pointed out in detail how sediment entering the bay can be reduced, considerable confusion still exists as to the effects of sediment in the bay. And a basic question remains unanswered: How much of the sediment entering the bay stays in the bay? Until additional insight is obtained as to retention of river sediments, inflows and outflows of marine sediments, and intra-bay mixing of sediments, the physical and economic evaluation of impacts of bay sediments will continue to be frustrating.

Many possible or potential beneficial and adverse economic effects remain unevaluated. Some items unevaluated in this study, but which would likely be affected by sediment reduction include:

- The commercial seafoods industry
- Sports fishing and hunting
- Flood damages
- The recreation and tourist industry
- Transportation modes, water versus land
- Agriculture, crop and pasture yields
- Municipal and industrial water quality
- Commercial and industrial port development.

This list is not meant to be all inclusive. Also, some of these, and others, have been evaluated from the standpoint of beneficial and adverse environmental and social well-being effects.

In the absence of precise, definitive data relating to sediment effects, different assumptions were constructed and evaluated. These assumptions were presented in the preceding section. The comparison of alternative sediment control programs or plans (Table X-2) is based on the assumed hypothesis that all sediment entering the bay stays in the bay.

For reasons already explained, this study does not present a preferred plan. Several alternative plans are shown on Table X-2 where the beneficial and adverse economic, environmental, and social well-being effects are evaluated. Again, it must be pointed out that not all of the effects of sediment reduction were evaluated.

In Table X-2, under Economic Development, are comparisons of amortized annual<sup>1/</sup> beneficial effects and costs of the different alternatives. At the 30 percent level of reduction, a \$102,380 net annual benefit is shown. At the 40 percent level, net annual benefits are negative -\$28,800, which suggest that selection of the 40 percent reduction plan would have to be based on criteria other than economics; i.e., net beneficial environmental or social well-being factors. Somewhere between the 30 and 40 percent reduction levels, net economic benefits become zero (the precise point was not determined). One might be tempted to conclude that the 30 percent level of reduction should be the sediment-reduction goal. Such a conclusion would be risky since economic beneficial and adverse effects do not give a complete picture. Environmental and social well-being factors should also have a bearing on the selection of a reduction goal and may be justification for a greater (or smaller) sediment reduction level.

Looking at the maximum reduction level, 64 percent, annual net benefits are a negative \$10 million. The reason for such a large negative benefit is that several costly control measures are required to achieve the maximum least-cost reduction. Comparing costs, it can be seen that a substantial increase is required for the 4 percent sediment reduction obtained going from the 60 percent reduction to the 64 percent reduction, from \$2,754,230 to \$14,142,620. The larger sediment-reduction levels would likely be prohibitive from an economic standpoint.

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<sup>1/</sup> Annual costs were amortized using the current interest rate (6 5/8 percent) in federal resource projects set by the Water Resources Council.

Table X-2.--Comparison of alternative control programs, all lands, Tillamook Bay Drainage Basin, 1975

Alternative Plans	Levels of Reduction						Maximum 64%
	10%	20%	30%	40%	50%	60%	
<u>Economic Development:</u>	\$	\$	\$	\$	\$	\$	\$
Average annual beneficial effects							
Reduced land loss.....	1,080	1,900	2,590	3,450	4,010	4,600	4,910
Reduction in sediment.....	19,390	38,780	58,180	77,570	96,970	116,360	124,180
Increased agricultural production....	--	--	--	--	--	--	374,200
Increased forest production.....	47,540	95,060	197,580	228,200	336,590	1,149,190	2,310,760
Employment							
Installation.....	1,010	2,370	7,030	14,350	41,170	105,960	501,700
O&M.....	1,140	2,680	7,950	16,220	46,530	119,760	567,040
TOTAL.....	70,160	140,790	273,330	339,790	525,270	1,495,870	3,882,790
Adverse effects							
Average annual cost of measures.....	26,330	63,350	170,950	368,590	1,046,290	2,754,230	14,142,620
Net beneficial effects.....	43,830	77,440	102,380	-28,800	-521,020	-1,258,360	-10,259,830
<u>Environmental Quality:</u>							
Beneficial and adverse.....	There would be 1,038 acres of improved wildlife habitat available as forage and cover. 1,058 acres would become usable as cover only in about 20 years.  There would be improved shading of about 50 miles of stream.  A slight improvement in water quality.  Less fine sediment to clog spawning gravels.  Improved visual quality of the stream environment.  Improved visual quality of another 207.5 acres of Tillamook Burn.  Improved visual quality of about 851 acres of old clearcuts.  Would reduce average annual sediment yield to Bay.  Loss of vegetative conditions necessary for wildlife habitat on 1.23 acres.	There would be 2,176 acres of improved wildlife habitat available as forage and cover. 2,117 acres would become usable as cover only in about 20 years.  Improved shading to about 130 miles of stream.  Some improvement of stream water quality.  A much-improved fish spawning environment.  Improved visual quality of the stream environment.  Temporary loss of wildlife habitat due to backsloping on 36.42 acres.  Rip rap would impair or destroy potential wildlife habitats due to lack of vegetation on 4.89 acres.  Improve visual quality of 415 acres of the Burn.  Improve visual quality of 1,702.25 acres on old clearcuts.  Would reduce average annual sediment yield to Bay.  Backsloping & revegetation would be subject to damage unless fencing is utilized.	There would be 4,390.93 acres of improved wildlife habitat available as forage and cover. 4,234.5 acres would become usable as cover only in about 20 years.  There would be a loss of 11.73 acres of shoreline habitat due to rock rip rap and pit run rock.  Improved shading to about 180 miles of stream.  Improved visual quality of the stream environment.  A temporary (1-3 years) disruption of instream environment on 3.82 acres of streambed.  A temporary loss of 66.83 acres of shoreline habitat due to backsloping.  A significant improvement in water quality.  Improve visual quality of 960 acres of the Burn.  Improve visual quality of 3,274.5 acres of old clearcuts.  Treatment measures will reduce sediment yield to Bay.  Backsloping & revegetation would be subject to damage unless fencing is utilized.	There would be 5,903.22 acres of improved wildlife habitat for forage and cover. 5,015.5 acres would become usable as cover only in about 20 years.  Improved shading on about 274 miles of stream.  A loss of 33.33 acres of shoreline habitat to rock rip rap and pit run rock.  A temporary loss of 43.23 acres of shoreline habitat due to backsloping.  Temporary disturbance of in-stream environment on 44.7 acres.  Water quality would be greatly improved.  Improved visual quality of streamside and roadside environment.  Backsloping & revegetation would be subject to damage unless fencing is utilized.  Improve visual quality of the Burn and of old clearcuts.  Treatment will reduce sediment to the Bay.  The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Volume of sediment deposited on croplands would be significantly reduced.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	There would be 14,120.87 acres of improved wildlife habitat for forage and cover. 7,486.5 acres would become usable only in about 20 years.  Improved shading of about 270 miles of stream.  Improved visual environment of streams and roadsides.  A loss of 64.56 acres of shoreline habitat.  Temporary disruption of 222.9 acres of stream bottom environment.  Temporary loss of 113.6 acres of shoreline habitat.  Water quality would become very good.  Backsloping & revegetation would be subject to damage unless fencing is utilized.  Improve visual quality of the Burn and of old clearcuts.  Treatment will reduce sediment yield to the Bay.  The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Sediment deposition on cropland would be greatly reduced.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	There would be 35,451.35 acres of improved wildlife habitat for forage and cover. 29,077.5 acres would become usable as cover only in about 20 years.  Improved shading of about 258 miles of stream.  Improved visual environment of stream and roadsides.  A loss of 76.56 acres of shoreline habitat to rock rip rap and pit run rock.  A temporary loss of 40.07 acres of shoreline habitat due to backsloping.  A temporary disruption of the instream eco-system.  Water quality would be excellent.  Spawning gravels would be relatively free of sediments.  Improve visual quality of the Burn and of old clearcuts.  Treatment will reduce sediment yield to the Bay.  The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Sediment deposition on cropland would be minor.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive. Some roads which are not usable during wet seasons could be used without damage to vehicles or resources.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	There would be 68,007 acres of improved wildlife habitat for forage and cover. 51,454.5 acres would become usable as cover only in about 20 years.  Improved shading of about 262 miles of stream.  The basin would have less of the Tillamook Burn aspect, and would have an excellent visual environment throughout.  Loss of 102.3 acres of shoreline habitat due to rock rip rap and pit run rock.  Temporary disruption of 215.8 acres of instream eco-system.  Water quality would be as near to the natural system as is possible today.  Salmon and steelhead runs would have maximum habitat available for propagation.  The impacts of flooding on loss of life and property due to sediment from forest lands is reduced to insignificance.  Sediment deposition on cropland would be minor.  Some banks would be safe for fishermen.  Roads would be safer to drive. The basin would be accessible by all-weather roads.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.
<u>Social Well Being:</u>							
Beneficial and adverse.....	The impact of floods on loss of life and property due to sediment would be slightly reduced.  Some stream banks treated would be safer for bank fishermen.  Cattle access trails would provide established entry into channel bottom and would also serve as natural drainageways for rapid removal of floodwater from farm operation areas.  Rip rap would provide improved protection for farm operations and urban development and would prevent loss of additional pastureland.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment would be noticeably reduced.  Volume of sediment deposited on crop lands would be partially reduced.  Some stream banks treated would be safer for bank fishermen.  Would provide improved access to channel area for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment would be significantly reduced.  Volume of sediment deposited on crop lands would be reduced noticeably.  Some stream banks treated would be safer for bank fishermen.  Would provide improved access to channel area for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Volume of sediment deposited on croplands would be significantly reduced.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Sediment deposition on cropland would be greatly reduced.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment would be greatly reduced.  Sediment deposition on cropland would be minor.  Some stream banks treated would be safer for fishermen.  Roads would be safer to drive. Some roads which are not usable during wet seasons could be used without damage to vehicles or resources.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.	The impacts of flooding on loss of life and property due to sediment from forest lands is reduced to insignificance.  Sediment deposition on cropland would be minor.  Some banks would be safe for fishermen.  Roads would be safer to drive. The basin would be accessible by all-weather roads.  Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.  Deferred grazing would improve existing pasture land.  Will provide better access to channel bottom for recreational purposes.  Rip rap could result in serious injuries with regard to access of personnel to channel.

1/ Average annual costs were amortized using the current interest rate in federal water resource projects set by the Water Resources Council (6 5/8 percent).



## IMPLEMENTATION CONSIDERATIONS

The study team has not developed a preferred or recommended alternative for this report. There are too many questions which remain unanswered at this time, the most critical of which is the establishment of sediment-reduction goal. These questions must be answered before a preferred alternative can be recommended.

The levels of sediment reduction as presented in this report are based upon a least-cost analysis of all alternative measures. The levels themselves were selected at 10 percent reduction levels except for the maximum which was dictated by the upper limit of feasible program accomplishment. This analysis was presented with specific constraints as noted in previous sections.

The local people anticipate utilizing data presented in this report as basic data inputs into a land-use plan for Tillamook County. The land-use plan is being developed under contract at this time. Decisions will be made by local people, hopefully including the aforementioned establishment of a sediment-reduction goal. Implementation of individual treatment measures selected through the county land-use planning process may be assisted by several federal programs. Potential sources of financial and technical assistance are quite varied and often require some prior knowledge of their existence. A publication is available entitled Catalog of Federal Domestic Assistance, which catalogs over 1,000 grant, loan, or technical advice and information programs administered by 55 Federal agencies.

The United States Department of Agriculture recognized the frustration which an individual or organization may experience in using this document. To help with this problem, the Department has computerized a portion of the catalog for programs which pertain to problems facing local governments. This program will search the records with a minimum of time and effort to identify programs in a particular category for which the applicant is eligible. The computer will print a list of the program titles and catalog numbers which can then be used to refer back to the 900-page catalog for more complete information. The Oregon State University Extension Service makes this resource available to communities of the State. Trained staff can assist interested community representatives in obtaining information. The service is available to both public and private individuals and groups.

The study team staff has searched the catalog and selected those programs which appear to have some potential application to the Tillamook study area. These are listed on Table X-3. Detailed descriptions of the programs and applications for assistance are available through the responsible agencies.

Some of the programs listed on Table X-3 may not have a direct relationship to erosion and sediment reduction. They may provide benefits to resources affected by erosion and sediment problems; monitor the erosion, sediment, and flood situation; provide means of enhancement of recreation, environmental, and economic values of natural resources upon which erosion and sediment problems may have an impact; and provide potential means of funding and employment to accomplish erosion and sediment reduction.

Various other means (other than federal-assistance programs) of promoting sediment reduction might also be considered in the planning of an implementation program. Some of these means could include:

- Educational programs and workshops
- Tax benefits
- New laws and regulations
- Stricter enforcement of existing laws
- Zoning
- Monetary incentives.

Formulation of a sediment-reduction plan will necessarily require the input of many individuals, groups, and agencies - local, state, and federal. An implementation plan requires that a sediment-reduction goal be established, and that funding sources be identified. The data and model presented in this report could be an important aid in the formulation of a sediment reduction implementation plan.

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction,  
Tillamook Bay Drainage Basin, 1978

Department, Agency, and Program	Short Title	Index <sup>1/</sup>	Relationship to Study	Type of Assistance <sup>2/</sup>
<u>U.S. DEPARTMENT OF AGRICULTURE:</u>				
ASCS-Agricultural Stabilization and Conservation Service				
Emergency Conservation Measures	ECM	10.054		B
Water Bank Program		10.062		B, K
Agricultural Conservation Program	ACP	10.063		B
Forestry Incentives Program	FIP	10.064		B
FHA-Farmers Home Administration				
Irrigation, Drainage, and other Soil and Water Conservation Loans		10.409		F
Recreation Facility Loans		10.413		F
Resource Conservation and Development Loans		10.414		F
Soil and Water Loans	SW	10.416		F
Watershed Protection and Flood Prevention Loans		10.419		F
FS-Forest Service				
Assistance to States for Tree Improvement	TITLE IV	10.655		B
Cooperative Forest Fire Control		10.656		A
Cooperation in Forest Management and Processing	CFM	10.657		A
Cooperative Forest Insect and Disease Management	FIDM	10.658		B
Cooperative Production and Distribution of Forest Tree Planting Stock		10.659		B
General Forestry Assistance	GFA	10.660		B
Youth Conservation Corps-Grants to States		10.661		B
Rural Community Fire Protection	RCFP	10.662		B
SCS-Soil Conservation Service				
Resource Conservation and Development		10.901		B, K
Soil and Water Conservation		10.902		K
Watershed Protection and Flood Prevention	PL-566	10.904		B, K
Plant Materials for Conservation		10.905		H
River Basin Surveys and Investigations	CRBS	10.906		J, K
<u>U.S. DEPARTMENT OF COMMERCE:</u>				
EDA-Economic Development Administration				
Economic Development-Grants & Loans for Public Works & Development Facilities		11.300	Flood Control	B, E
Economic Development-Support for Planning Organizations		11.302		B
Economic Development-Public Works Impacts Projects		11.304	Jobs for Unemployed	B
Economic Development-State & Local Economic Development Planning		11.305		B
Economic Development-District Operational Assistance		11.306		B
Economic Development-Special Economic Development and Adjustment Assistance Program		11.307		B
Grants to States for Supplemental & Basic Funding of Titles I, II, III, IV, and IX Activities		11.308		
Redevelopment Area Loan Program	204	11.310		E

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction, Tillamook Bay Drainage Basin, 1978. (continued)

[illegible]

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction,  
Tillamook Bay Drainage Basin, 1978. (continued)

U.S. DEPARTMENT OF THE INTERIOR:

Bureau of Land Management  
Public Land for Recreation, Public Purposes, and  
Historic Monuments  
Public Land for Right-of-Way

Recreation Planning Development  
15.202  
15.203

Bureau of Outdoor Recreation  
Outdoor Recreation-Aquisition, Development, and  
Planning  
Outdoor Recreation-Technical Assistance

Land & Water Conservation Fund Grants  
15.400  
15.402

Fish and Wildlife Service  
Fish Restoration  
Sport Fish Technical Assistance

Restore Sports Fishing  
Sediment Effects on Fish Runs  
15.605  
15.608

Geological Survey  
Water Resources Investigations

Stream Flow & Sediment Monitoring  
15.804

Office of Water Research and Technology  
Additional Water Resources Research

Research  
15.950

Water Resources Research-Assistance to State  
Institutes

Research  
15.951

Water Resources Research-Matching Grants to  
State Institutes

Research  
15.952

Water Resources Scientific Information Center

Technical Information  
15.953

TITLE II

WRSIC

U.S. DEPARTMENT OF LABOR:

Employment and Training Administration

Job Corps  
Employment & Training Institutional Grants  
Comprehensive Employment & Training Programs  
Employment & Training Research and Development  
Projects

Sediment Control Project Training  
Training for Planners  
Job Training & Employment  
17.211  
17.219  
17.232

CETA

17.233

U.S. DEPARTMENT OF TRANSPORTATION:

Federal Highway Administration  
Highway Research, Planning, & Construction

Disaster & Other Road Repair  
20.205

Federal Railroad Administration  
Railroad Rehabilitation & Improvement - Guarantee  
of Obligations  
Railroad Rehabilitation & Improvement - Redeemable  
Reference Shares

20.309  
20.310

U.S. CIVIL SERVICE COMMISSION:

Federal Employment for Disadvantaged Youth - Summer  
Federal Summer Employment  
Training Assistance to State & Local Governments

Summer Aids Program  
Summer Jobs  
27.004  
27.006  
27.009

U.S. NATIONAL SCIENCE FOUNDATION:

Intergovernmental Program

Local Government Technology Integration  
47.036

U.S. COMMUNITY SERVICES ADMINISTRATION:

Community Action  
Community Economic Development

Unemployment Relief  
Unemployment Relief  
49.002  
49.011

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction,  
Tillamook Bay Drainage Basin, 1978. (continued)

<u>U.S. SMALL BUSINESS ADMINISTRATION:</u>					
Economic Injury Disaster Loans					E, F
Physical Disaster Loans					E, F
	EIDL DL	59.002 59.008			
<u>U.S. WATER RESOURCE COUNCIL:</u>					
Water Resource Planning	TITLE III	65.001			A
<u>U.S. ENVIRONMENTAL PROTECTION AGENCY:</u>					
Office of Water and Hazardous Materials					
Water Pollution Control - State and Interstate Program Grants	106	66.419	Water Pollution Control		A
Water Pollution Control - State and Local Manpower Program Development		66.420	Manpower Training		B
Water Quality Control Information System- Orientation/Training Seminars, Data and Monitoring Publications	STORET	66.423			M
Water Pollution Control - State and Area-wide		66.426			B
Water Quality Management Planning Agency		66.431	Partly Relates to Dredging		E
Water Pollution Control Loans					
Office of Research and Development					
Environmental Protection - Consolidated Research Grants		66.500			B
Water Pollution Control - Research, Development, and Demonstration Grants		66.505			B
Office of Planning and Management					
Environmental Protection Consolidated Grants- Program Support		66.600			B
Environmental Protection Consolidated Grants- Special Purpose		66.602			B
<u>PACIFIC NORTHWEST REGIONAL COMMISSION:</u>					
Pacific Northwest Regional Economic Development	TITLE V	76.001			B
Pacific Northwest Technical and Planning Assistance		76.002	Demonstration Projects		
Pacific Northwest Regional Transportation		76.004	Transportation Modes (Barging Logs?)		B

1/ For more information, see Catalog of Federal Domestic Assistance, OMB, Washington, D.C.

2/ A-Formula Grants, B-Project Grants, C-Direct payments for specified use, E-Direct loans, F-Guaranteed/insured loans, G-Insurance, H-Sale, exchange, or donation of property and goods, J-Provision of specialized services, K-Advisory services and counseling, L-Dissemination of technical information, M-Training, O-Federal employment, P-Research contracts.

## MANAGERIAL STRATEGIES

Several alternative plans to reduce sediment were developed during the course of this study. For reasons that are stated elsewhere in this report, an implementation plan was not developed. There will be a need to continue to provide assistance after conclusion of this study, during implementation phases. This continued cooperative effort should include detailed problem analysis based upon problem-specific data, and an analysis of the future situation based upon proposed future land resource management objectives.

Some problem relationships must be explained to obtain a clearer picture of the least-cost combination of selected alternatives. Some alternative measures do not appear until the 60 percent solution, and others do not enter until the maximum solution. Yet, there may be instances when a preferred solution at, say, the 30 percent level should include one or more measures that are not a part of the least-cost combination at the 30 percent level. Some of these situations will be discussed next.

### 1. Roads and trails related to gullies and landslides.

Many miles of roads and trails in the study area are currently contributing an insignificant amount of sediment when the total existing problem is analyzed. The potential exists for some of these trails to become serious gullies and landslides. This potential cannot be ignored in the selection of treatment measure alternatives.

Motorcycle trails, for example, which are nearly parallel (plus or minus 30°) to the slope on steep (50% plus) terrain in those areas noted as having a severe or very severe potential erosion hazard, must be considered if future, more serious problems are to be prevented. Many trails already exceed 2 feet in depth and could be accelerated into a landslide or massive gully by a major storm event.

Landslides begin to enter the solution at the 30 percent level. There is a causal relationship between some of the existing slides and some roads. All slides selected for treatment must be examined for this potential situation. When a causal relationship between a road and a slide exists, the road problem must also be treated at the same time if slide stabilization efforts are to be effective.

## 2. The problem with averages.

Sediment rates used in the least-cost model are estimated averages for each kind of sediment source for each of the sub-watersheds. The costs and effects of alternative treatment measures are also estimated averages. Solutions selected by the least-cost model are based upon these averages. Selection of individual problem sources to receive indicated treatment measures must be based upon field examination of all applicable source areas. Examination of source areas would be appropriate until all sources of a specific problem entered at the maximum possible sediment reduction. An example follows.

Channel bank stabilization is called for on forested lands for 29.7 acres at the 10 percent level. The balance of 70.8 acres enters at the 30 percent level. All 70.8 acres would have to be examined on the ground to select the 29.7 acres to be treated at the 10 percent level.

## 3. Multiple goal considerations.

The least-cost selection of alternative treatment measures is based on the goal of sediment reduction to the bay. In some instances, other goals may take precedence. For example, the least-cost sediment control solutions for several reduction levels include rock riprap. However, decision makers may decide that rock riprap is not a desirable solution because of environmental or other considerations. Thus, these other considerations, or goals, may take precedence over the goal of achieving sediment reduction at least cost. When these other considerations become known, they can be translated into constraints for the least-cost solutions; e.g., no more than so many acres of rock riprap.

## 4. Treatment measures to solve nonsediment problems.

Decision makers and planners must not lose sight of alternative treatment measures at levels above the selected goal. Again, referring to Number 2 preceding, the rates, costs, and effects used in the model are averages. If the goal is to reduce sediment by 40 percent, management must not lose sight of those problem sources and treatment measures which come in at the 50 and 60 percent solution levels. There may be source areas and treatment measures at these higher levels which, when viewed on an individual basis, would be preferred over a selected least-cost sediment reduction source or treatment. Resource management goals, environmental goals, or other economic factors not related to sediment reduction may influence this decision. Examples of this situation follow.

All feasible channel bank critical erosion is selected by the model for treatment at the 30 percent level. Some slides are also selected at that level. Additional slides come in at the 40-50 percent levels. There may be a slide at the 40 percent level which, when viewed on an individual basis, should be corrected for reasons other than sediment control; e.g., a slide blocking a key access road or an anadromous fish stream. Resource management and environmental goals may dictate selection of that particular slide over a source selected by the model at the lower reduction level.

#### 5. The importance of goal selection prior to implementation.

Selection of a sediment-reduction planning goal is important prior to implementation of treatment measures selected by the model. This point is demonstrated by the following example.

Channel bank stabilization on forested lands enters the 30 percent solution on 66.8 acres. The treatment measure is to backslope and plant brush. At the 40 percent level only 6 acres of channel banks would be treated by backsloping and planting brush. For the model to achieve a 40 percent reduction, it was necessary to go to rock rip-rap which reduces sediment by a larger amount. If a plan were implemented at the 30 percent level and later changed to the 40 percent level, then the backsloping and brush planting, already installed, would not be a part of the 40 percent solution. It would have been more efficient to have implemented the 40 percent plan directly rather than using measures from the 30 percent plan as a "stepping stone." Proposed changes to a sediment reduction goal should be examined carefully to avoid inefficient allocations of treatment resources.

#### 6. A note on restoration versus prevention

Many of the major forested land-erosion problems stem from several destructive fires that have occurred over the last 60 years. A number of these old erosion problems still exist today. To a large extent, this study concentrated on these chronic erosion problems. Many treatment measures shown in this study are restorative in nature; aimed at correcting old erosion problems.

Resource managers now distinguish between resource capability and resource suitability. Resource capability is defined with reference to the productive capacity or the potential of fixed resources to produce valuable (in an economic sense) renewable resources. Resource suitability is defined in terms of the appropriateness of harvesting, or otherwise making use of the resource. For

example , a steep, forested slope may have the capability of producing commercial timber, but because of a severe erosion potential or other adverse environmental consequences, resource managers may decide that the timber is unsuitable for intensive management due to environmental constraints and the limitations of present technology.

The distinction between capability and suitability is important. In terms of erosion and sediment control programs, suitability relates to preventive control measures rather than restorative measures. Several on-going programs in the basin are preventive; that is, aimed at preventing erosion problems from occurring in the future even though no present erosion problem exists. Advanced logging systems, and establishment of cover crops on agricultural lands prior to the fall and winter rainy seasons, are examples of preventive control practices.

Preventive techniques are better understood today because of improved resource inventories relating capability and suitability. Better decisions are being made today because of improved technology and management's willingness to understand and mitigate the environmental risks.

The study team concentrated on major erosion problems as they existed during the course of study. Future or potential sources of erosion, and corresponding preventive treatment measures were not a specific study objective. Preventive, on-going treatment measure programs should be continued and strengthened.

## FUTURE CONSIDERATIONS - THE MODEL

In the previous section on managerial strategies, several suggestions were made relative to implementation planning. The computer model that was used to help develop least-cost combinations of control measures is on file and available. It could be put to beneficial use during the implementation- planning process. Ways in which the model could be of further use are explained next.

- Any number of constraints can be placed on treatment measures and sediment sources. Suppose, for example, rock riprap was determined not to be an acceptable solution in some sub-basins. The model could be re-run for a least-cost solution with rock riprap constrained to less than a specified number of acres.
- The model can be used to determine how much sediment reduction is possible, subject to a limit of funds available for sediment-control measures. Suppose, for

example, \$100,000 were made available for sediment control. The model could be used to determine the treatment measures that would bring about the largest sediment reduction with that amount of money.

- This study dealt with sediment. Since erosion rates are already in the model, it could be rerun with erosion reduction as the objective. Least-cost solutions for specified levels of erosion reduction would then be the model output.
- Erosion and sediment could be combined into joint objective functions.
- The model could be run to solve for the least-cost sediment (or erosion) control measures for any combination of the 16 sub-basins. Forested lands could be run separately from agricultural lands, for example.
- As the time goes by, changes will occur in the acreages of erosion sources. Also, changes will occur in erosion and sediment rates by source. Significant changes, mostly increases, will occur for control costs. To some extent, particularly on forested, publicly owned lands and on large timber holdings, programs have been planned far into the future. These planned changes could be run through the model to develop future strategies for erosion and sediment control.

Another model, input-output, is available and could be of use during implementation planning. The input-output model was developed specifically for the Tillamook economy. It could be used to evaluate the secondary economic effects of an implementation program on major economic sectors in the Tillamook County economy.



# GLOSSARY



# GLOSSARY

Aggradation	To build up grade or slope of a channel by deposition of sediment.
Amphibole	A mineral composed largely of silica, calcium, and magnesium. (ex. - hornblende, asbestos).
Anadromous	Fishes which spend part of their lives in the ocean but move into fresh water to spawn.
Andesite	Fine-grained, dark gray rock of volcanic origin containing phenocrysts of feldspar and darker minerals.
Annelid	Worm with a body made of joined segments or rings.
Augite	A black, complex silicate mineral occurring in basic igneous rocks.
B.P.	Before present - 1950.
Basalt	A hard, heavy, dark colored rock of volcanic origin.
Breccia	A rock consisting of sharp cornered fragments of glacial or volcanic origin which are cemented together with sand or clay.
Coefficient	<p>Coefficient of Correlation is a statistical term for the measure of dependence of one variable or another variable.</p> <p>Coefficient of Determination is a statistical term which is the ratio of the explained variation to the total variation. Mathematically, it is the square of the coefficient of correlation.</p>
Crustacean	A class of invertebrates that live in water and breathe through gills (shrimp, crab, etc.)
Dendrite	Tree-like; branching in form.
Detrital	Fragments of rock, etc.; produced by disintegration or wearing away.

Diabase	A dark colored igneous rock made up largely of augite and feldspar.
Diopside	A kind of pyroxene, usually transparent.
Diorite	A dark gray or greenish igneous rock, consisting chiefly of feldspar and hornblende.
Dipteras	A large group of insects having one pair of membranous wings (housefly, mosquito, etc.)
Diurnal	Daily; happening each day.
Ecology	Branch of biology that deals with the relations between living organisms and their environment.
Eocene	Period of geologic time. Earliest epoch of Tertiary Period during which mammals became the dominant animals.
Estuarine	Formed or deposited in an estuary.
Estuary	A semi-enclosed coastal water body having free connection with the open sea with which sea water is measurable mixed with fresh water drained from the land.
Eutrophication	A means of aging of a body of water whereby aquatic plants and marine life are abundant and waters are deficient in oxygen.
Feldspar	Crystalline minerals made up of aluminum silicates and found in igneous rocks.
Fluvial	To flow; found in or produced by a river or rivers.
Gabbro	Dark, heavy igneous rock composed chiefly of pyroxene and feldspar.
Geanticline	A great upward folding of the earth's crust.
Holocene	Recent epoch of geologic time.
Hypersthene	A greenish-black mineral of the pyroxene group, a silicate of iron and magnesium.
Kilometer	A unit of length or distance, equal to 1000 meters.

Lacustrine	Sediment deposits in or on lakes.
M.S.L.	Mean sea level.
Micaceous	Characteristic of mica (thin, transparent, easily separated layers).
Miocene	Period of geologic time. Third era of tertiary Period characterized by development of large mountain ranges.
Nonopaque	Letting light pass through substances.
Oligocene	Period of geologic time. Second epoch of Tertiary Period characterized by the development of the higher mammals.
Olivine	A silicate of magnesium and iron, existing usually as green crystals and used as a semiprecious stone.
Orthopyroxene	Regular silicate mineral containing iron, magnesium, and calcium found in igneous rocks.
Pileated	Having a crest extending from the bill to the nape ( ex. woodpecker).
Pixel	Decision model for establishing erosion control strategies.
Pleistocene	Period of geologic time. First epoch of Quaternary Period characterized by rise and recession of continental ice sheets and by the appearance of man.
Pliocene	Period of geologic time. Last epoch of the Tertiary Period during which modern plants and animals were developed.
Pyroxene	A complex silicate mineral containing iron, magnesium, and calcium and found in igneous rocks.
Quasistationary	In a sense stationary or not moving.

Rill	A groove, furrow or long, narrow, shallow trench.
Riverine	Of, like, or produced by a river or rivers.
Sheet	A layer of soil that is broad in extent and comparatively thin.
Shoaling	When a ridge of sand or silt is deposited across the mouth of a river resulting in shallow water.
Spatial	Happening or existing in space.
Temporal	Lasting only for a time; temporary.
Terrestrial	Consisting of land as distinguished from water.
Tertiary	First period of Cenozoic Era or its system of rocks.
Transgressive	Tending to overstep or go beyond.
Tuffaceous	Of or like tuff, a porous rock formed by consolidation of volcanic ash and dust.
Winnowing	To analyze or examine carefully in order to separate the various elements.

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